Democratic Socialist Republic of Sri Lanka

Ministry of Mahaweli Development

Maduru Oya Project

Feasibility Report

Annex E
Agronomic Studies

ACRES Acres International Limited, Niagara Falls, Canada

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FOREWORD

The Feasibility Report on the Maduru Oya Project, of which this Annex forms a part, is made up as follows:

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ACKNOWLEDGEMENTS

During 1978-79, a great number of people unselfishly contributed their time, knowledge and understanding to these "Agronomic Studies" of System B. This long list includes the following.

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SUMMARY

The agronomic studies reported herein focus on

- the evaluation of the crop production potential of land and water resources in System B

- the identification of the present crop production problems, and the recommendation of measures that would contribute to their solution

- the identification of cropping patterns that are both agronomically and economically feasible

- the estimation of crop water requirements

- the recommendation of a package of inputs that would optimize crop production and maximize net benefits

- the estimating of expected yield levels associated with the recommended cropping pattern.

Present Situation

Agriculture in System B follows the centuries-old Dry Zone pattern. Apart from shifting chenas covering some 6,600 ha of uplands, cropping in System B is an activity which is confined to land developed under a few major irrigation schemes and many minor irrigation and rainfed schemes. Paddy covers all of the existing irrigated land area.

A varying extent of chenas carries annuals, mainly cereals, pulses, and root crops. Perennials (coconuts and fruits) and vegetables generally occupy homestead plots.

PRESENT AGRICULTURAL LAND USE IN SYSTEM B (ha)

Land Use	Total Area	Percent of Agriculture	Percent of System
Irrigated (Paddy)			
Major schemes	5 021	24.8	4.1
Minor schemes (<80 ha)	2 294	11.4	1.9
Rainfed, floodplains	6 289	31.1	5.0
Subtotal	13 604	67.3	11.0
Active Chena	6 600	32.7	5.3
Grand Totals	20 204	100.0	16.3

Existing paddy production practices generally involve

- widespread use of improved varieties
- buffalo power in Polonnaruwa District and tractor power in Batticaloa District
- the broadcasting of seed where the water supply is inadequate
- handweeding supplemented by chemicals
- widespread use of pesticides and insecticides
- sporadic and suboptimal use of fertilizer
- hand harvesting and buffalo threshing.

Land use is generally restricted because of water shortages and even the technology employed is largely determined by water availability. Nevertheless, average paddy yields are relatively high. In most areas, yields range from 2.5 to 3.5 tonnes/ha in Yala and 3.5 to 4.5 tonnes/ha in Maha. In the Pimburettewa Scheme, crop-cutting experiments carried out by the consultant confirmed that yields in the 3.5 to 4.5 tonnes/ha range are obtained there in Yala and yields in the

4.5 to 6.0 tonnes/ha range are obtained in Maha. Isolated farms sometimes record yield in excess of 7.0 tonnes/ha. Yields tend to be highly correlated with water stress which is a function of the type of irrigation available (major, minor and rainfed) which, in turn, greatly affects the technology employed.

At the same time, chena cultivation is widespread, usually in conjunction with paddy cultivation, virgin jungle, shrub jungle, short-cycle fallow, or "permanent" cultivation. Existing chena production practices are generally rudimentary and typical of subsistence agriculture in a tropical environment. Yet most food crops for home consumption are successfully grown on chena and homesteads without recourse to commercial channels.

Production and marketing support tends to be limited to paddy production, and even this is generally inadequate. Existing social and physical infrastructure in the region could not accommodate a large immigration of farmers without extensive public support.

In short, the existing agronomic situation in System B is relatively static, despite some technological change in recent years. The principal limit to future development is the lack of rainfall in the Yala season.

Potential With Project

With the proposed Maduru Oya project, the net irrigable area in System B would be approximately as follows

Paddy (two crops)	34 300 ha
Upland (two crops)	1 500 ha
Total	35 800 ha

Expected average yields, in tonnes/ha for the "with project" situation are as follows.

Basic Land Class	Season Maha	Yala
1R	4.6	4.6
2R	4.1	4.1

These projected yields, which are based on the yields observed in 1979-80 in the Pimburettewa Scheme, are expected to be achieved by the average farmer after 5 yr.

All crops would be produced using an intermediate level of technology which would be heavily dependent on commercial development of the agricultural sector. A "package" of farm inputs would be readily available to farmers in the region and product markets would be secured. All the attendant social and physical infrastructure required to develop the region fully would accompany the on-farm development proposals detailed in the main body of this report. In essence, the Maduru Oya project would represent an integrated rural development program for System B.

Numerous alternative crops are identified for the uplands and paddy is recommended for the lowlands. The agronomic advantages and disadvantages of each alternative upland crop are discussed and some alternative cropping patterns are indicated. The water requirements for paddy and a "typical" upland crop rotation are also provided. The report includes a summary of the agronomic requirements for the region before the anticipated project benefits can become a reality. Farm input requirements are indicated for all major crops identified, as are seasonal farm labor and farm power requirements. A discussion follows regarding how the delivery system for both farm inputs and farm products might be strengthened so that it would stimulate agricultural development in System B.

A detailed proposal to restructure the existing agricultural extension service can be found in Annex K (Organization and Management). In essence, this involves an integrated program for adaptive research, training and extension in the project area. The proposed research program would be conducted on an "Experimental Demonstration Farm".

1 - INTRODUCTION

1.1 - Purpose and Scope

The agronomic studies reported herein focus on

- the evaluation of the crop production potential of land and water resources in System B

- the identification of the present crop production problems, and the recommendation of measures that would contribute to their solution

- the identification of cropping patterns that are agronomically feasible and provide satisfactory economic and financial returns

- the estimation of crop water requirements

- the recommendation of a package of inputs that would optimize crop production and maximize net benefits.

The assessment of soils in Annex B makes it abundantly clear that the Maduru Oya project will be essentially a paddy project. Irrigated paddy has accordingly been treated in more detail in the present annex than have upland crops.

Other annexes containing material directly related to these agronomic studies are

- Annex A - summary of present land use and existing infrastructure

- Annex B - detailed information on soils and land classification

- Annex C - calculations of system water requirements
- Annex F - discussion on integration of livestock into farming systems
- Annex G - agroeconomic aspects of crops and farming systems
- Annex K - discussion of proposed agricultural extension and cooperative systems

2 - PROJECT SETTING*

System B covers a gross area of some 130 000 ha, distributed over the Districts of Polonnaruwa (56 percent), Batticaloa (42 percent), and Amparai (2 percent).

The project area lies along both sides of the Maduru Oya downstream from the Maduru Oya damsite, which is located approximately 32 km south of Welikanda. It is bounded on the southwest by the Hungamala Ela and System C, on the northwest by the floodplain of the Mahaweli Ganga, on the north by System A, on the east by the lagoon lying inland from the Bay of Bengal, and on the southeast by the Meeyankolla Ela. Physiographically, the area is an old erosion surface with generally subdued topography broken by outcrops of rock ridges or isolated knobs. These outcrops are less frequent in the northern part of the project area.

2.1 - Soils

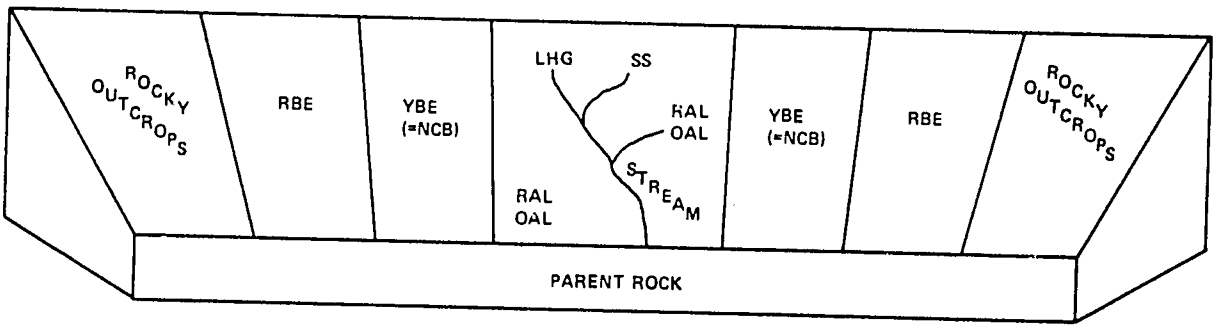
To assist the nonsoil specialist to evaluate more precisely the interaction of soils and crop agronomy, the following notes have been prepared. Further details can be found in Annex B.

*See also Annex A (The Project Area) and Annex B (Soils and Land Classification).

Six principal soil groups occur in the Maduru Oya project area. These are

- The Reddish Brown Earths (RBE)
- The Noncalcic Brown Soils (NCB) (also called Yellow Brown Earths - YBE)
- The Low Humic Gley Soils (LHG)
- The Recent Alluvial Soils (RAL) of the Maduru Oya and Mahaweli Ganga
- The Old Alluvial Soils (OAL)
- The Solodized Solonetz Soils (SS).

The approximate topographic location of these soils is illustrated in the accompanying sketch.



The Upland category consists of well to moderately well drained RBE, NCB and upper levee bank soils. This group is never waterlogged for any appreciable time during the year. The RBE's are generally deep, well-drained soils which have a quartz gravel or stone line of variable thickness at some depth in the "B" horizon. Only about one-third of the RBE's are suitable for irrigation, regardless of the command level. The NCB's are generally moderately well-drained, deep brown to yellowish brown in color, and consist of loamy sands or sandy loams.

The lowlands include the imperfectly drained RBE's, the imperfectly drained NCB's, and the imperfectly to very poorly drained Recent Alluvial, Old Alluvial, Low Humic Gley and Solodized Solonetz soils. These are generally sandy loam or sandy clay textured soils.

The Lowland group of soils is naturally waterlogged throughout the rainy season and well into the dry season. Flooding after heavy rains can be expected.

The following soil distribution has been found to prevail over the project area.

Upland:	RBE	16.0 percent)	
	NCB	12.1 percent)	28 percent
Lowland:	RBE	7.2 percent)	
	NCB	22.9 percent)	
	LHG	3.2 percent)	
	OAL	20.0 percent)	60 percent
	SS	0.5 percent)	
	RAL	7.0 percent)	
Misc./Unclassified		11.1 percent	
Total		100.0 percent	

2.2 - Climate and Rainfall

Traditionally, but inappropriately, the 75-in. (1,900-mm) isohyet has demarcated the Dry Zone of Sri Lanka from the Wet Zone. In recent years, however, most meteorologists have inclined to the view that the area with a precipitation under 10 in. (250 mm) in the 5-month period (May-September) that is dominated by the Southwest Monsoon should be recognized as the Dry Zone, and the area with a precipitation exceeding 20 in. (500 mm) during the same period be called the Wet Zone. The area with a May-September rainfall of 10-20 in. (250-500 mm) composes the Intermediate Zone.

Two rain gauging stations--Welikanda in the Polonnaruwa District and Vakaneri in the Batticaloa District--provide rainfall data in System B. Rainfall data for the years 1951 to 1961 at these two stations are summarized in Table E-2.1.

During the May to September period, Welikanda and Vakaneri show mean values of 247 mm and 291 mm/month, respectively. The mean annual values for Welikanda and Vakaneri are 1,885 mm and 2,039 mm/yr respectively.

On both the traditional and the recently accepted criteria mentioned above, Welikanda falls just within the Dry Zone and Vakaneri lies on the fringe of the Intermediate Zone. Admittedly, the precipitation varies widely between years and because the distributions are positively skewed (via the disproportionate contributions of rare but heavy downpours) the median would be a more satisfactory estimate than the arithmetic mean. Figure E-1 depicts the Agroecological Zones in the vicinity of the project area, as proposed by the Land Use Division (LUD) of the Irrigation Department.

TABLE E-2.1

RAINFALL AT WELIKANDA AND VAKANERI, 1951 - 1961*

(mm)

	May-Sept		Oct-Feb		March-Apr		Annual Rainfall	
	Weli-kanda	Vaka-neri	Weli-kanda	Vaka-neri	Weli-kanda	Vaka-neri	Weli-kanda	Vaka-neri
Mean(mm)	247	291	1521	1617	117	132	1885	2039
Standard Error	±34.6	±45.3	±170.9	±131.9	±22.8	±24.4	±163.4	±125.3

*See Annex C for further details of rainfall covering the 1950 - 1977 period.

The calculation of confidence limits provides a statistically satisfactory approach to problems of rainfall expectancy. The limits of rainfall expectancy at a probability level of 0.5 are plotted in Figure E-2 (Welikanda) and Figure E-3 (Vakaneri), and demonstrate the potentials and hazards of annual cropping in System B. With the methods used, the positive skewness mentioned earlier has been accommodated by using the transformation log (x + c), where x is the 3-wk moving total, and c is an inverse function of the regression of the standard error on the mean[1].

The rainfall patterns at both locations are those characteristic of the Agroecological Zone DL_2. The annual rainfall distribution in Zone DL_1 has two rainfall peaks per year, with a smaller peak in Yala than in Maha. The distribution in Zone DL_2, on the other hand, tends to produce a rainfall peak only in Maha, which rises to a considerably higher value than the comparable peak in Zone DL_1. The irrigation requirements of even 5- to 6-month upland crops in System B are low in Maha (see Annex C) i.e., successful rainfed cropping is possible. In Yala, on the other hand, almost all crop water requirements must be provided by irrigation.

Accompanying temperature variations are not wide: mean monthly temperature ranges from 25.4°C in January to 29.5°C in June. Sunshine hours are lowest in December (5.7 h/day) and highest in March (9.1 h/day). If conditions for crop growth are otherwise optimal, yields would be higher in Yala than in Maha. Wind velocities are particularly high during June to September (310-396 km/day) and low in December to April (51-78 km/day). These variations in wind velocity are reflected in parallel changes in evapotranspiration estimates.

Meteorological data specific to System B are available from the nearby meteorological station established on the Kaudulla Irrigation Scheme by the Overseas Development Unit of the Hydraulics Research Station, UK, and the Institute of Hydrology, UK. The station is operated jointly with the Irrigation Department, Sri Lanka. The absence of a well-equipped meteorological station within the System B area is a deficiency which should be remedied as soon as possible.

3 - PRESENT SITUATION IN THE PROJECT AREA

3.1 - Introduction

Agriculture in System B presently follows the centuries-old Dry Zone pattern. Apart from shifting chenas covering some 6,600 ha of uplands, cropping in System B is an activity which is presently confined to land developed under a few major irrigation schemes and many minor irrigation and rainfed schemes. Paddy covers all of the existing irrigated land area, as shown in Table E-3.1.

A varying extent of chenas carries annuals, mainly cereals, pulses, and root crops. Perennials (coconuts and fruits) and vegetables generally occupy homestead plots.

Existing irrigated and chena production in System B are both discussed in the following paragraphs.

3.2 - Irrigated Cultivation

Present land use in System B is comparable to that of the rest of the Dry Zone: paddy to the near exclusion of all other crops dominates the irrigated areas. Irrigated cultivation in the project area follows three systems

- irrigation under major tanks
- irrigation under minor tanks
- lowland rainfed cultivation, primarily in river flood plains.

TABLE E-3.1

PRESENT AGRICULTURAL LAND USE IN SYSTEM B
(ha)

Agricultural Land Use	Polonnaruwa District	Batticaloa District	Total Area	Percent of Agric	Percent of System[2]
Irrigated (Paddy)[4]					
Major schemes	1 232	3 789	5 021	24.8	4.1
Minor schemes	1 895	399	2 294	11.4	1.9
Rainfed, flood-plains	674	5 615	6 289	31.1	5.0
Subtotals	3 801 (28 %)	9 803 (72 %)	13 604	67.3	11.0
Active Chenal[1,3]			6 600	32.7	5.3
Grand Totals			20 204	100.0	16.3

Notes:

[1]Source - interpretation of aerial photographs taken in March 1979.

[2]As a percent of the total area photographed, approximately 123 800 ha.

[3]Actual cultivation in any one year is approximately 6,600 ha. Total for a 5-yr rotation is 32 800 ha.

[4]Source - Department of Census and Statistics. Discrepancies between these figures and those used elsewhere are due to different definitions of "irrigated area" and to the sometimes nebulous distinction between "rainfed" and "minor tank scheme". Overall agreement between official statistics and areas taken from the aerial photographs is satisfactory.

The first type is to be found in three schemes--Pimburettewa, Vakaneri and Punanai*. Pimburettewa is a recent colonization scheme, initiated in 1969 and completed in 1976. The second type is found in association with the Purana (traditional) villages. The third type is a recently developing activity by people that usually live in nearby villages, whether inside or outside the project area.

Lowland rainfed cultivation of the river floodplains dominates cultivation in the southeast part of the project area and is expanding. The major floodplains are that of the Maduru Oya/Kuda Oya downstream from the Pimburettewa Scheme, and the river courses of two minor rivers, Ambawinne Ela, and Meeyankolla Ela, both flowing from west to east on the Right Bank of the Maduru Oya. The latter two areas are characterized by coarse sandy soils (the Old Alluvials) which are submerged or waterlogged during much of the Maha season but dry out during Yala. Only one paddy crop in Maha is possible. In the Maduru Oya floodplain, the yearly floods generally allow for the sowing of paddy before the floods, but in some parts sowing for a late Maha crop is done after the floods.

3.2.1 - Paddy Area and Cropping Intensity

Asweddumized hectarages and cropping intensities in System B are summarized in Table E-3.2.

*While the Punanai Scheme has no major tank associated with it, its position on the lower Maduru Oya gives it a reliable water supply for Maha crops.

TABLE E-3.2

PADDY IN SYSTEM B: AREA AND CROPPING INTENSITIES, 1973 TO 1979

District	Grama Sevaka Divisions	Major Schemes: Asweddumized Area (ha)	Major Schemes: Area Sown Maha (ha)	Major Schemes: Area Sown Yala (ha)	Major Schemes: Cropping Intensities Maha (%)	Major Schemes: Cropping Intensities Yala (%)	Minor Schemes: Asweddumized Area (ha)	Minor Schemes: Area Sown Maha (ha)	Minor Schemes: Area Sown Yala (ha)	Minor Schemes: Cropping Intensities Maha (%)	Minor Schemes: Cropping Intensities Yala (%)	Rainfed Areas: Asweddumized Area (ha)	Rainfed Areas: Area Sown Maha (ha)	Rainfed Areas: Area Sown Yala (ha)	Rainfed Areas: Cropping Intensities Maha (%)	Rainfed Areas: Cropping Intensities Yala (%)	Total: Asweddumized Area (ha)	Total: Area Sown Maha (ha)	Total: Area Sown Yala (ha)	Total: Cropping Intensities Maha (%)	Total: Cropping Intensities Yala (%)
Polonnaruwa	Kandakadu	-	-	-	-	-	140	140	38	100	27	112	112	-	100	0	252	252	38	100	15
	Mutugalla	-	-	-	-	-	218	214	70	98	32	102	93	14	91	14	320	307	84	95	26
	Makuppe	-	-	-	-	-	178	137	27	77	15	77	76	-	99	0	255	213	27	84	11
	Karapola	-	-	-	-	-	439	384	107	87	24	109	107	-	98	0	548	491	107	90	20
	Manampitiya	-	-	-	-	-	437	374	78	86	18	59	58	-	98	0	496	432	78	87	16
	Pimburettewa	792	722	344	91	43	207	176	136	85	66	131	119	-	91	0	1 130	1 017	480	90	42
	Yakkure	-	-	-	-	-	113	51	9	45	8	5	4	-	80	0	118	55	9	47	8
	Aralaganwila	440	440	157	100	36	163	152	32	93	20	79	74	-	94	0	682	656	189	98	28
TOTAL		1 232	1 162	501	94	41	1 895	1 628	497	86	26	674	643	14	95	2	3 801	3 433	1 012	90	27
Batticaloa	Miravodai	869	589	267	68	31	1	1	-	100	-	7	2	-	29	0	877	392	267	68	30
	Kiran	466	226	196	48	42	139	93	21	67	15	565	488	2	86	0.4	1 170	807	219	69	19
	Thawouai	664	523	181	79	27	-	-	-	-	-	5	2	-	40	0	669	525	181	78	27
	Kongolai	-	-	-	-	-	47	21	10	45	21	3 007	2 152	63	72	2	3 054	2 173	73	71	2
	Vahulayalai	1 507	1 412	365	94	24	27	19	-	70	-	1 032	714	31	69	3	2 566	2 145	396	84	15
	Wadamunai	164	72	65	44	40	31	11	12	35	39	136	65	9	48	7	331	148	86	45	26
	Kirimichai	119	74	45	62	38	154	141	10	92	7	863	696	-	81	0	1 136	911	55	80	5
TOTAL		3 789	2 896	1 119	76	30	399	286	53	72	13	5 615	4 119	105	73	2	9 803	7 301	1 277	74	13
Amparai	Unuwatara-babula	-	-	-	-	-	6	4	3	67	50	66	26	-	39	0	72	30	3	42	4
TOTAL		5 021	4 058	1 620	81	32	2 300	1 918	553	83	24	6 355	4 788	119	75	2	13 676	10 764	2 292	79	17

Source: Department of Census and Statistics.

Note: Data from this table, combined with areas measured from aerial photographs and cropping data obtained from the Irrigation Department, form the basis for projected situation "Without the Project", as summarized in Table 7.3 of the Main Report.

Of the total asweddumized extent of 13 700 ha, the Batticaloa District contains 9,800 ha (72 percent) and the Polonnaruwa District 3,800 ha (28 percent).

In the Polonnaruwa District, the highest proportion (43 percent) falls under the minor irrigation schemes and the smallest (18 percent) is rainfed. In the Batticaloa District, the reverse is true: most of the asweddumized land (57 percent) is rainfed,* and the smallest extent (4 percent) is under minor irrigation schemes.

In System B, seasonal cropping intensities are consistently higher in the Maha season (79 percent) than in Yala (17 percent), and annual intensities are considerably higher in the Polonnaruwa District (117 percent) than in the Batticaloa District (87 percent). The difference in Maha between major and minor irrigation schemes is not significant, but in Yala the major schemes have a markedly higher cropping intensity. The overall cropping intensities in Yala under the major and minor irrigation schemes are 32 percent and 24 percent respectively. Understandably, there is virtually no Yala cultivation in rainfed areas. Present differences in cropping intensities basically reflect variations in the available water supply.

*The rainfed category in Batticaloa District is dominated by the lands on the floodplain of the Maduru Oya. This accounts for much of the difference in distribution of rainfed and small tank scheme lands.

3.2.2 - Paddy Production Practices

(i) Use of Improved Varieties

The use of improved varieties entails less recurrent expenditure than do other forms of input use,* and accordingly receives emphasis in the developing countries. Sri Lanka's achievements in the field of paddy breeding in the last three decades have been spectacular. Apart from their yield potential, the cultivars recently released from the Central Rice Breeding Station at Batalagoda manifest many virtues, including resistance to lodging and grain shedding, and resistance to a wide range of diseases and pests. A list of the recent releases is presented in Table E-3.3.

In the Second International Rice Yield Trials sponsored by the International Rice Research Institute, and conducted in the 1974/75 dry season at eight locations in India, Malaysia, Mexico, Colombia, Nigeria and the Philippines, the Batalagoda release, BG90-2, topped the list of varieties under test with an average yield of 6.8 tonnes/ha of paddy. Actually, this cultivar has a potential yield of over 8 tonnes/ha.

The Batalagoda cultivars are now widely used in System B, particularly in the Polonnaruwa District. During the period 1973-1978, an average of 73 percent of the Polonnaruwa District fields carried these cultivars (Table E-3.4): most of them were sown in BG 11-11 (in Maha) and BG 34-8 (in Yala). In Yala 1979, every one of the fields sampled in crop-cutting surveys under the Pimburettewa Scheme in the

*Seed can be reserved for the subsequent crop for a limited number of years, with a possible drop in yield in each year.

TABLE E-3.3

CULTIVARS BRED AT THE CENTRAL RICE BREEDING STATION, BATALAGODA AND SUBSTATIONS

Cultivar	Year of Release	Growth Duration (mo)	Panicle Weight (g)	Panicle No./Plant	Sterility (percent)	Shattering (percent)	Grain Length (mm)	Grain Width (mm)	Culm Height (cm)	Dormancy (wk)	Bushel Weight (lb)	Amylose (percent)	Protein in Brown Rice (percent)	Resistance to—* Blast	Resistance to—* Bacterial Leaf Blight	Resistance to—* Gall Midge
BG 276-5	1979	3	4.4	7.9	11.4	7.3	8.3	3.0	64	3	47	25.0	11.6	R	MR	R
BG 94-2	1978	3-1/2	3.3	11.3	11.0	9.0	7.9	2.8	67	4	47	26.4	8.9	R	MR	S
AT - 16	1978	3-1/2	3.2	11.1	6.9	5.0	6.0	2.4	60	4	46	25.4	9.0	HR	MS	S
BG 400-1	1979	4-1/2	3.0	9.4	6.9	4.5	8.2	2.9	80	5	45	26.2	9.0	R	R	R
BG 90-2	1975	4	3.6	8.0	7.9	4.0	9.0	2.6	69	4	47	25.0	8.7	R	R	S
BG 94-1	1975	3-1/2	3.4	12.0	10.2	9.0	9.3	2.7	61	4	45	26.1	8.7	R	MR	S
BG 33-2	1971	3	3.6	9.5	11.0	6.0	7.75	3.1	67	4	45	25.6	12.4	HR	MS	S
BG 34-8	1971	3-3-1/2	4.2	8.4	13.0	7.0	7.49	3.06	63	5	48	27.0	11.5	MR	MR	-
BG 34-6	1971	3-1/2	4.1	10.0	9.0	9.0	8.11	3.17	65	3	47	27.5	10.6	MR	S	S
BG 11-11	1970	4-1/2	2.9	9.6	9.6	17.8	5.67	2.83	81	5	48	25.6	10.2	HR	R	S
H-4	1958	4-1/2	4.5	8.0	9.8	3.0	9.23	3.19	113	4	46	28.2	9.7	HR	MS	S

*HR - Highly Resistant, R - Resistant, MR - Moderately Resistant, MS - Moderately Susceptible, S - Susceptible.

Source: Dr. D. Senadhira, Head, Central Rice Breeding Station, Batalagoda

TABLE E-3.4

PADDY IN SYSTEM B: RECENT SPREAD OF IMPROVED PRACTICES

District	Season/Year	Percentage of Fields					
						Sown in Improved Cultivars	
		Transplanted	Fertilized	Weedicide Applied	Insecticide Applied	Recent Releases	Older Releases
Polonnaruwa	Maha 73/74	25	50	13	0	60	40
	Yala 74	17	63	25	0	67	0
	Maha 74/75	6	50	10	47	70	30
	Yala 75	54	35	8	4	69	0
	Maha 75/76	33	28	8	18	47	42
	Yala 76	46	21	8	30	75	0
	Maha 76/77	63	56	6	79	70	22
	Yala 77	100	33	0	17	100	0
	Maha 77/78	84	78	16	81	80	0
Batticaloa	Maha 73/74	0	96	61	0	10	82
	Yala 74	0	33	33	0	18	6
	Maha 74/75	0	72	64	43	6	79
	Yala 75	0	71	50	42	18	29
	Maha 75/76	0	93	64	69	1	93
	Yala 76	0	94	67	76	9	13
	Maha 76/77	0	96	48	65	0	96
	Yala 77	0	100	21	54	33	38
	Maha 77/78	0	99	75	84	10	71

Source: Department of Census and Statistics

Polonnaruwa District were planted with a recent Batalagoda release--mainly BG34-8. In this area at least, the spread of improved varieties has reached the saturation point.

In the Batticaloa District, where water stress is extensive and weed competition correspondingly severe, the situation is different: since the recent Batalagoda releases are mostly dwarfs or semidwarfs (60 to 80 cm) which do not compete effectively with weeds on broadcast fields, the Batticaloa District farmers generally grow traditional varieties or the tall early Batalagoda releases--mostly H-4.

The spread of recent and early Batalagoda releases in the two districts of System B is illustrated in Table E-3.5.

(ii) Land Preparation

For ploughing, harrowing and leveling fields after the issue of irrigation water, farmers have a choice of 4-wheeled or 2-wheeled tractors, animal power or manual labor. In the Polonnaruwa District, nearly all land preparation is done by buffalo; tractors are rarely used. In the Batticaloa District, on the other hand, most of the land is prepared by tractor. Shortages of farm power frequently occur and lead to the consumption of more irrigation water due to delays in planting.

Paddy cultivation practices are largely dependent on the soil type and the irrigation facilities available. Generally speaking, land preparation starts after the first rains in September. Most fields in the river floodplains are ploughed twice and harrowed once. Although the fields are bunded, no full leveling is applied. Only one ploughing occurs in the Maduru Oya floodplain, because the risk of flooding is very high. Under tank schemes, paddy land preparation is also

TABLE E-3.5

SPREAD OF PADDY VARIETIES, 1973-1978 (DCS Survey)

	Numbers of Fields Carrying--					
	Recent Batalagoda Releases (mostly BG11-11 & BG34-8)		Early Batalagoda Releases (mostly H-4)		Traditional Varieties	
	(No.)	(Percent)	(No.)	(Percent)	(No.)	(Percent)
Polonnaruwa District	166	72.5	39	17.0	24	10.5
Batticaloa District	46	10.5	272	61.8	122	27.7

dependent on rainfall because insufficient water is usually left in the tank at the end of the Yala season. If the soil is of a fine texture with a clay content of 15 percent or more (RBE/LHG), the limits between dry and wet for a good ploughing are narrow. In general, the farmer will prefer a fully saturated soil before he starts preparing the land.

The farmer is dependent on the amount of rainfall and the availability of farm power for timely land preparation. In practice, he will generally not be in a position to do the ploughing, the puddling and leveling in a time period short enough to give his crop the best start. If the soils are of the sandy type (Old Alluvials and NCB's), ploughing under dry conditions (after one or two rains) is easier and also practicable under continuing rainfall. Most farmers will try to have their fields ready for sowing or transplanting at the moment that the chance for a good crop is as great as possible. Under the tanks, this is generally rather late in the Maha season, and basically not very different from a rainfed situation.

(iii) Broadcasting/Transplanting

Fields can be broadcast with sprouted seed (103 kg/ha) or nurseries can be sown (52 kg/ha) and 21-day seedlings transplanted. As Table E-3.4 indicates, a progressive increase in the proportion of fields transplanted has occured in recent years in the Polonnaruwa District: the percentage of fields transplanted in Yala 1977 and Maha 1977/78 were 100 percent and 84 percent respectively. The cultivars used were generally BG11-11 in Maha and BG34-8 in Yala. Normally very early varieties do not benefit by transplanting and are broadcast; BG34-8 (3 to 3-1/2 months) is an exception.

For tank schemes, planting is done as late as December or even January when the farmer is sure that the water in the tank is sufficient to irrigate the paddy during the full cropping period. In this system most of the rainfall which would have been sufficient for growing half of the crop during October-November is lost. In the rainfed condition of the floodplains, the paddy has to be sown well ahead of the major floods that are expected from early December to mid January. If the crop is at least 40 days old by the time of inundation, it will survive most normal floods (up to 60 cm for a few days). If the crop is too young (by late sowing or early floods) it will be lost almost completely. The farmers in these conditions are bound to a limited time frame for land preparation and sowing. This results in poor land preparation and very little puddling and/or leveling. Fields after one or two ploughings are freed from weeds as much as possible and the paddy is broadcast before the end of October. Transplanting is only practised under the tanks where the land is well prepared, by means including puddling. This is common practice for the Maha crop, but the Yala crop is still mainly broadcast, except for limited transplanting under the major tanks.

The popularity of transplanting in the Polonnaruwa District is related to the reliable supply of irrigation water, and the fact that the early settlers in this area came from the Kandy and Kegalle Districts where transplanting is traditional. The Batticaloa District presents a contrast: mainly on account of the precarious water supply and the prevalence of larger, absentee-held farms, the paddy crop has always been broadcast.

(iv) Weed Control

Hand weeding is supplemented by weedicidal control, particularly in the Batticaloa District where the percentage of fields receiving weedicide applications has ranged from 21 percent to 75 percent since 1973. In the Polonnaruwa District during the same period, where weed control by transplanting and inundation is general, the use of weedicides is rare: in Yala 1977 when 100 percent of the fields were transplanted, none received a weedicide application. Where row planting is practised, mechanical weeders are in use.

In System B, the preferred weedicide is propanil (3,4 D[illegible]).

(v) Pests and Diseases

The practice of staggered planting aggravates the problem of pests which include brown hoppers, leaf rollers, gall midges, stem borers, thrips and paddy bugs. There has, however, been an increasing trend toward pesticide use: the percentage of fields treated with insecticides has risen from zero in 1973/74 to 81 percent and 84 percent in Maha 1977/78, in the Polonnaruwa and Batticaloa Districts respectively.

Diseases present no major problems in System B: the Batalagoda cultivars grown in the area resist the ubiquitous blast disease.

Bacterial blight is not troublesome in the Dry Zone. In any event, the cultivars commonly grown in the Polonnaruwa District -- BG11-11 and BG34-8 -- are resistant to bacterial leaf blight.

(vi) Fertilizer Use

Farmers in System B generally follow the fertilizer rates and application methods recommended by the Department of Agriculture. Actual fertilizer use in System B has been limited, however, due to intermittent suppliers, relative profitability, and farm cash constraints. The percentage of farmers actually using fertilizers has varied over the years 1973 to 1978 from 21 percent to 78 percent in the Polonnaruwa District, and from 33 percent to 100 percent in the Batticaloa District.

Table E-3.6 outlines the types of fertilizer, methods of application and application rates which are recommended by the Department of Agriculture.

(vii) Harvesting and Threshing

As in the rest of the country, paddy is generally hand-harvested by sickle, threshed by tractor or buffalo, winnowed and bagged. Threshing causes about 10 percent damage to the paddy. The moisture content of the grain is about 18 percent at harvest, but is brought down to 15 percent or less before it is stored.

3.2.3 - Present Paddy Yields

In view of the crucial importance of the paddy crop, its existing and future production potential is given particular attention in this report. There had been no previous attempt to collect objective and valid paddy statistics specific to System B. The calculation of net benefits relating to rice has in the past been based on yield estimates of doubtful reliability.

Action under the present feasibility study took the form of

(a) reprocessing by the Department of Census and Statistics (DCS) of their 1973 - 1978 crop-cutting survey data

TABLE E-3.6

RECOMMENDED FERTILIZATION PRACTICES FOR PADDY

Fertilizer	Time of Application	Rate: Three 3-1/2 Months Varieties (kg/ha)	Rate: Four 4-1/2 Months Varieties (kg/ha)
VI: a mixture of 2.6 percent N, 27.4 percent P and 12.9 percent K	At second ploughing or before planting	190	190
Urea	2 wk after planting	60	60
Urea	6 wk after broad-casting or 4 wk after transplanting	95	60
Urea	10 wk after broad-casting or 8 wk after transplanting	-	95

Source: Department of Agriculture

(b) monitoring by the Agronomist and his counterpart of a crop-cutting survey conducted in System B in Yala 1979 by DCS

(c) executing a separate crop-cutting survey under the Pimburettewa Scheme in Yala 1979 by the Agronomist and his counterpart

(d) executing a separate crop-cutting survey in both the Pimburettewa and Vakaneri schemes in Maha 1979/80 by the Agronomist and his counterpart.

Data under (a) covered all areas in System B; data under (b) was confined to the section of System B that falls within the Polonnaruwa District. The surveys took the form of stratified random sampling with weightage for extent: random villages and random fields (kumburas) within each village were selected.

3.2.3.1 - DCS Crop-Cutting Surveys

(a) The 1973 - 1978 Surveys

Random sample surveys executed by the Department of Census and Statistics over the period 1973 to 1978 provide objective and statistically valid yield estimates covering the whole of System B: the yield data provided by these surveys are summarized in Table E-3.7.

In the Polonnaruwa District, Maha yields are considerably higher under the Pimburettewa Scheme (6.5 ± 0.25 tonnes/ha) than on the minor irrigation schemes (3.9 ± 0.23 tonnes/ha) and rainfed areas (4.3 ± 0.41 tonnes/ha).

TABLE E-3.7

PADDY IN SYSTEM B: YIELDS IN CROP-CUTTING SURVEYS, 1973 - 1978

		Yields of Paddy in Tonnes per Hectare					
		Maha Season			Yala Season		
District	Years	Major Irrigation Schemes	Minor Irrigation Schemes	Rainfed Areas	Major Irrigation Schemes	Minor Irrigation Schemes	Rainfed Areas
Polonnaruwa	1973/74	6.8	3.9 ± 0.25	4.2	6.1	2.2	–
	1974/75	7.1 ± 0.48	3.4 ± 0.21	3.0	3.1 ± 0.60	2.6 ± 0.22	–
	1975/76	6.7 ± 0.83	3.4 ± 0.33	3.0	4.0 ± 0.41	2.4 ± 0.17	–
	1976/77	6.4 ± 0.36	4.4 ± 0.78	4.6	2.9 ± 0.22		–
	1977/78	5.8 ± 0.44	4.9	5.3 ± 0.65		1.8 ± 0.25	–
	Mean	6.6 ± 0.25	4.0 ± 0.23	4.0 ± 0.41	4.0 ± 0.31	2.3 ± 0.13	–
Batticaloa	1973/74	2.5 ± 0.24	2.2 ± 0.22	1.9 ± 0.26	2.4 ± 0.14	2.5	2.2
	1974/75	2.6 ± 0.13		2.6 ± 0.17	2.5 ± 0.19	3.4	2.3
	1975/76	2.9 ± 0.15	2.6	2.2 ± 0.15	2.9 ± 0.17	2.1	1.5
	1976/77	3.1 ± 0.14	–	2.9 ± 0.17	2.8 ± 0.08	–	2.0
	1977/78	3.0 ± 0.13	2.3 ± 0.17	2.4 ± 0.16	2.8 ± 0.07	2.4	–
	Mean	2.8 ± 0.08	2.4 ± 0.12	2.4 ± 0.09	2.7 ± 0.06	2.6 ± 0.20	2.0 ± 0.16

Source: Department of Census & Statistics

At the same time, Maha yields in the Batticaloa District are much lower than those in the Polonnaruwa District: the Batticaloa District yields under the major irrigation schemes (2.8 ± 0.08 tonnes/ha) are less than half those in the Polonnaruwa District. Moreover, the yield superiority of the major irrigation schemes over other schemes in the Batticaloa District is not as pronounced as in the Polonnaruwa District. Even the major schemes manifest water stress in the Batticaloa District during the Maha season.

The yield data presented in Table E-3.7 underline the paramount importance of a reliable water supply. In the Polonnaruwa District, under the Pimburettewa Scheme, Maha yields reach extraordinarily high values--5.8 to 7.1 tonnes/ha -- and indicate the potential of improved cultivars on System B soils when the water supply is adequate. Conversely, yields drop to low values--under 2 tonnes/ha--under conditions of water stress.

Mean yields weighted for the asweddumized hectarage are tabulated below.

MEAN YIELDS WEIGHTED FOR
ASWEDDUMIZED HECTARAGE
(tonnes/ha)

	Polonnaruwa District	Batticaloa District	System B
Maha	4.7	2.6	3.2
Yala	2.8	2.5	2.5

Estimates of total paddy production in System B are presented in Table E-3.8.

TABLE E-3.8

ESTIMATED PRESENT PADDY PRODUCTION IN SYSTEM B

Season	District	Scheme	Mean Yield (t/ha)	Asweddumized Area* (ha)	Cropping Intensity (percent)	Paddy Production
Maha	Polonnaruwa	Major irrigation	6.5	1 303	94	7 961
		Minor irrigation	3.9	2 171	86	7 282
		Rainfed	4.3	578	92	2 287
						17 530
Maha	Batticaloa	Major irrigation	2.8	3 985	76	8 480
		Minor irrigation	2.3	457	72	757
		Rainfed	2.4	5 039	73	8 828
						18 065
Yala	Polonnaruwa	Major irrigation	3.6	1 303	41	1 923
		Minor irrigation	2.3	2 171	26	1 298
		Rainfed	-	578	-	-
						3 221
Yala	Batticaloa	Major irrigation	2.7	3 985	30	3 228
		Minor irrigation	2.6	457	13	154
		Rainfed	2.1	5 039	2	212
						3 594
						42 410

*In 1978.

(b) <u>The Yala 1979 DCS Survey in the Polonnaruwa District</u>

This survey covered 48 random fields: 20 under the Pimburettewa Scheme, and 28 under minor schemes; data relating to these two categories are presented in Tables E-3.9 and E-3.10. The mean yield for the Pimburettewa Scheme was 4.9 ± 0.27 tonnes/ha and that for the minor schemes was 2.7 ± 0.15 tonnes/ha.

The spread of improved practices under these schemes was as shown below.

	Percentage of Fields			
	Transplanted	Fertilized	Treated With Weedicide	Treated With Insecticide
Major schemes	55	85	5	80
Minor schemes	11	75	7	25

Differences between input levels do not provide a simple explanation of the striking yield differences between schemes. The lower yields under the minor schemes are basically an expression of their exposure to different levels of water stress. Even the lower percentage of transplanted fields in the minor schemes can be attributed to this cause.

3.2.3.2 - <u>Crop-Cutting Surveys Executed in 1979-80 by Acres Inernational Limited</u>

Crop-cutting surveys conducted by DCS in the Maha season on major irrigation schemes in System B during the period 1973

TABLE E-3.9

CROP-CUTTING SURVEY BY DCS ON THE PIMBURETTEWA SCHEME, YALA 1979

Crop Cut No.	Tract	Soil Series	Farmer	Inputs[2]	Paddy Yield[3] (t/ha)
1	5	-4	K.G. Wijeratne	TF	3.964
2	5	-	T.V. Jamis	TF	4.171
3	5	-	R.P. Rajaratna	TFI	4.678
4	5	-	S.M. Gunesekera	TFI	4.194
5	6	Damminewela	W. Wijedasa	FI	5.828
6	6	Padumundakulam	R.S. Appuhamy	TFI	4.605
7	7	Damminewela	R.K. Punchina	F	6.054
8	6	Damminewela	K.M. Banda	FI	4.974
9	6	Padumundakulam	W.H. Gunatilaka	TFI	4.218
10	6	Padumundakulam	W.G. Somadasa	TFI	4.652
11	6	-	Y.K. Nandoris	FI	5.683
12	6	Padumundakulam	N. Wijepala	TI	6.777
13	6	-	S.M. Panbanda	TI	5.670
14	6	-	P.B. Simona	-	3.140
15	7	Alawakumbura	P.W. Kiribanda	FI	4.057
16	7	-	A.G. Somapala	TFI	5.055
17	7	Alawakumbura	H.M. Menikrala	TFI	7.116
18	7	Alawakumbura	R.A. Chandrasen	F	4.733
19	7	Alawakumbura	R.M. Appuhamy	FWI	4.186
20	7	Alawakumbura	P.G. Appuhamy	FI	4.379
Mean Yield and Standard Error					4.9 ± 0.23

Notes:

[1]All 20 random fields carried cultivar BG 34-8.
[2]Symbols: T = transplanted, F = fertilizer applied, W = weedicides applied, I = insecticides applied.
[3]DCS measures yield by volume, and conversion to tonnes/ha is made by multiplying by a conversion factor which is determined experimentally for standard moisture conditions.
[4]Soil series not identified.

TABLE E-3.10

CROP-CUTTING SURVEY BY DCS ON MINOR IRRIGATION SCHEMES, POLONNARUWA DISTRICT, YALA, 1979

Crop Cut No.	Village	Cultivar	Inputs[1]	Paddy Yield[2] (t/ha)
1	Kandakadu	BG 34-8	F	2.989
2	Kandakadu	BG 34-8	F	2.512
3	Kandakadu	BG 34-8	F	2.512
4	Kandakadu	BG 34-8	F	2.084
5	Mutugalla	BG 34-8	-	2.084
6	Mutugalla	BG 34-8	F	1.674
7	Mutugalla	BG 34-8	TF	3.140
8	Mutugalla	H-10	F	2.834
9	Mutugalla	BG 34-8	-	1.674
10	Mutugalla	BG 34-8	-	1.489
11	Tamankaduwa	BG 34-8	TF	4.766
12	Tamankaduwa	BG 34-8	TF	3.887
13	Tamankaduwa	BG 34-8	F	3.381
14	Tamankaduwa	BG 34-8	I	3.735
15	Tamankaduwa	BG 34-8	-	3.284
16	Tamankaduwa	BG 90-4	FW	2.898
17	Karapola	BG 34-6	FI	2.737
18	Karapola	BG 34-8	-	1.046
19	Karapola	H-10	F	3.171
20	Karapola	BG 34-6	FI	2.318
21	Karapola	BG 34-8	FI	2.962
22	Karapola	BG 34-8	-	2.157
23	Manampitiya	BG 34-8	FI	2.383
24	Manampitiya	BG 34-8	F	2.883
25	Manampitiya	BG 34-8	F	2.125
26	Manampitiya	PG 34-8	FWI	3.132
27	Manampitiya	BG 34-8	FI	3.381
28	Manampitiya	BG 34-8	F	3.011
Mean Yield and Standard Error				2.7 ± 0.15

Notes:

[1]Symbols: T = transplanted, F = fertilizers applied, W = weedicide applied, I = insecticide applied.

[2]DCS measures yield by volume, and conversion to tonne/ha is made by multiplying by a conversion factor which is determined experimentally for standard moisture conditions.

to 1978 placed the mean paddy yield at 6.5 $\pm$ 0.25 tonnes. This figure was considerably higher than the subjective estimates submitted by consultants for various Mahaweli projects. There was clearly a need for rechecking estimates of target yields (i.e. yields that may be expected when existing constraints are eliminated) during the feasibility study before these figures were used in economic analysis: hence, the decision to execute the crop-cutting surveys that are reported below. In addition, such surveys would (a) provide updated information on the present prevalence of, and the yield response to, improved agronomic practices, and (b) test the validity of the proposed system of land classification for rice (Annex B).

The methods used in the feasibility study surveys did not differ materially from those now in use in the stratified random-sample surveys executed by DCS, except that

- the harvested plot size was smaller - 0.001 ha for the feasibility study surveys, versus 0.0025 ha for DCS surveys in 1979*

- the measure of yield was the weight (and not the volume) of the winnowed harvest.

In the Maha 1979/80 survey, paddy was dried to 15 percent moisture or below, before weighing.

*Prior to 1979, DCS surveys were based on harvested plot sizes of 0.005 ha.

A feature of the feasibility surveys was the relatively complete enumeration of the major factors affecting rice yields including soil categories, cultivars, fertilizer levels, agrochemical inputs and cultural practices. Indeed, in the 30-yr history of crop-cutting experiments in Sri Lanka, the surveys conducted provide the first instance of complete identification of the soil series in crop-cut locations.

The two major irrigation schemes selected for the conduct of the Surveys - Pimburettewa and Vakaneri - present conspicuous contrasts.

- Fields cultivated under the Pimburettewa Scheme are free of water stress, at least in the Maha season. On the other hand, insufficiency of water afflicts the Vakaneri Scheme in both seasons.

- Cultivation standards implicit in water availability and control are predictably higher in the Pimburettewa Scheme.

- Agrochemical inputs (weedicides and pesticides) are heavier in the Vakaneri Scheme.

- Every farmer in the Pimburettewa Scheme has a 1.2-ha holding. The holding size in the Vakaneri Scheme varies from 1 to 13 ha, with a mean of 4.0 ± 0.62 ha.

In sum, Pimburettewa conditions approximate more closely what is envisaged "with Project" in System B, and accordingly, present Pimburettewa yields may be assumed to be a fair indicator of "with Project" yields.

(i) The Yala 1979 Survey

Only the Pimburettewa Scheme was surveyed in Yala 1979. Table E-3.11 lists crop cuts in 19 random fields in the Pimburettewa Scheme. The mean yield under this Scheme was 4.05 $\pm$ 0.28 tonnes/ha - a figure that is 15 to 20 percent lower than the comparable figure in the DCS Survey for the Pimburettewa Scheme in the same season. All fields sampled under this survey carried the recent Batalagoda release, BG 34-8.

A 't' function calculated for the difference between transplanting and broadcasting indicates that transplanted plots do not significantly outyield broadcast plots. Comparable results were obtained in the DCS Survey in Pimburettewa Scheme in Yala 1979.

The unexpected and relatively poor performance of transplanted fields in Yala is attributed primarily to the occurrence of some measure of water stress, which could have depressed transplanted yields more markedly than broadcast yields. For the "with Project" situation where Yala water stress would be alleviated to a considerable degree, it is proposed that all cultivars be transplanted.

(ii) The Maha 1979/1980 Survey

This survey was executed on a much more ambitious scale than the previous season's, and included both the Pimburettewa and Vakaneri Schemes. The Maha Pimburettewa Survey included 17 fields surveyed in the previous Yala season plus an additional 28 fields. Fields surveyed under the Vakaneri Scheme totaled 24.

Complete data for these two schemes are presented in Tables E-3.12 and E-3.13.

TABLE E-3.11

CROP-CUTTING SURVEY EXECUTED BY ACRES INTERNATIONAL ON PIMBURETTEWA SCHEME IN YALA, 1979

Crop Cut No.	Farmer	Soil Series[2]	Fertilizer Levels Used N (kg/ha)	P_2O (kg/ha)	K_2O (kg/ha)	Other Inputs	Paddy Yield[3] (t/ha)
1	R.M. Dharmadasa	Ma	0	0	0	T	2.91
2	P.B. Ranatunga	Ma	60	17	8	WI	3.53
3	H. Martin	G4	118	34	16	T	3.53
4	R. G. Lokubanda	G4	87	0	0	-	4.15
5	W. Amanis-singho	Pa	87	0	0	TI	2.94
6	D.K. Premadasa	Mn	118	34	16	T	2.91
7	M.G. Peter	Aa	162	34	35	-	3.11
8	K.M. Appuhamy	G4	42	34	16	-	2.49
9	K.G. Mudiyanse	G4	67	24	14	TI	5.09
10	H.M. Piyadasa	Pa	90	34	16	I	5.19
11	K.M. Punchibanda	Aa	75	34	16	WI	4.57
12	O.K. Piyadasa	M	104	34	16	TW	3.95
13	P.H. Guruge	Pa	115	0	0	TW	6.64
14	M.P. Premawathi	Aa	115	0	0	WI	4.90
15	E.G. Ariyadasa[1]	Up	72	0	6	-	4.90
16	R.H. Ratnayake	Pa	118	34	16	T	3.74
17	H.G. Kiribanda	Pa	87	0	0	T	3.95
18	A.G. Punchibanda	-	62	0	13	TWI	6.35
19	W.K. Sirisena	-	0	0	0	-	2.08

Mean Yield and Standard Error: 4.05 ± 0.28

Notes:

[1]Crop cuts No. 1 to 17 are taken from the same farms in Tables E-3.11, E-3.12 and E-3.14.

[2]Soil series are identified in Annex B.

[3]Corrected for moisture content by subtracting 8 percent from the observed yield at harvest time. This figure was the average correctic factor indicated by the Maha 1980 surveys.

[4]This soil series is not recommended for development with the project.

Symbols: T = transplanted
W = weedicides applied
I = insecticides applied

TABLE E-3.12

CROP CUTTING SURVEY EXECUTED BY ACRES INTERNATIONAL ON PIMBURETTEWA SCHEME IN MAHA 1979/1980

Crop Cut No.	Farmer	Soil Series[2]	Cultivar	Planting Method	Application of Inputs: Fertilizers	Weedicides	Pesticides	Yield[3] (t/ha)
1	R.M. Dharmadasa	Ma	BG11-11	B	<X	0	0	2.76
2	P.B. Ranatunga	Ma	BG34-8	T	X	0	X	4.04
3	H. Martin	G[4]	BG34-8	T	<X	0	0	3.65
4	R.G. Lokubanda	G[4]	BG34-8	B	X	0	0	2.76
5	W. Emanis Singho	Pa	BG11-11	T	X	0	X	6.47
6	D.K. Premadasa	Mn	BG34-8	T	X	X	0	6.43
7	M.G. Peter	Aa	BG11-11	T	X	0	0	7.11
8	K.M. Appuhamy	G[4]	BG11-11	B	X	0	X	4.04
9	K.G. Mudiyanse	Pa	BG11-11	T	<X	0	0	5.44
10	H.M. Piyadasa	Aa	BG11-11	T	X	0	X	4.96
11	K.M. Punchibanda	G[4]	BG34-8	B	0	0	X	4.56
12	O.K.D. Piyadasa	M	BG11-11	T	X	0	X	5.52
13	P.H. Guruge	Pa	BG11-11	T	X	0	X	6.95
14	M.P. Premawathie	Aa	BG11-11	T	X	0	X	6.73
15	E.G. Ariyadasa	Up	BG90-2	T	X	0	X	4.61
16	R.M. Ratnayake	Pa	BG11-11	T	X	0	X	6.29
17	H.K. Kiribanda	Pa	BG34-8	T	<X	0	X	4.65
18	L.P. Ukkumanike	K	BG11-11	T	0	0	0	5.38
19	K.D. Amarasi	K	BG34-8	T	<X	0	X	6.33
20	J.M. Tikiribanda	K	BG34-8	B	X	0	X	3.99
21	H.M. Heenbanda	M	BG34-8	T	<X	0	0	5.09
22	R.G. Yasawathi	M	BG34-8	T	<X	0	0	5.44
23	R.B. Piyadasa	Up	BG90-2	T	X	0	X	5.36
24	D.R. Appuhamy	Aa	IR8	B	0	0	0	3.80
25	D.M. Punchiappuhamy	Bo	BG34-8	T	<X	0	X	4.74
26	M.D. Vincent	Ma	BG34-8	T	<X	0	0	4.56
27	R.B. Somawathie	K	BG34-8	T	<X	0	0	3.07
28	S. Nissanka	Bo	BG11-11	T	X	0	X	6.94
29	R.B. Jayawardena	Ma	BG11-11	T	X	0	X	7.13
30	K.G. Somadasa	K	BG11-11	T	0	0	0	7.43
31	J.P. Piyadasa	M	BG34-8	T	<X	0	0	4.74
32	G.M. Tikiribanda	M	BG11-11	T	X	0	0	3.64
33	E.M. Tikiribanda	Pa	BG34-8	B	X	X	0	4.78
34	G.K. Dingiribanda	Aa	BG11-11	T	X	0	X	4.76
35	P.G. Rambanda	K	BG11-11	T	<X	0	X	6.22
36	D.M. Amaradasa	D	BG276-5	T	X	0	X	6.92
37	S. Tilakaratne	P	BG90-2	T	<X	0	0	6.04
38	K. Sugathadasa	M	BG34-8	T	X	0	X	5.33
39	W.G. Wickremasinghe	Aa	BG11-11	T	X	0	0	6.14
40	G.R. Somadasa	Pa	BG34-8	B	<X	0	X	3.93
41	G.R. Somadasa	Pa	BG11-11	T	X	0	X	6.28
42	H.M. Manikrala	Pa	BG11-11	T	X	0	X	7.35
43	B.G. Chandrapala	Aa	BG34-8	B	X	0	X	4.14
44	A. Saranelis	Aa	BG34-8	B	<X	X	X	3.59
45	D.R. Dayawathie	Aa	BG11-11	T	<X	X	0	5.20

Notes:
[1]Crop cuts Nos. 1 to 17 are taken from these same farms in E-3.11, E-3.12 and E-3.14.
[2]Soil series are identified in Annex B.
[3]Yields are at a moisture content of approximately 15 percent.
[4]This soil series is not recommended for development with the project.

Symbols: B = Broadcast
T = Transplanted
X = Applied at or above recommended level
<X = Application below recommended level
0 = not applied.

TABLE E-3.13

CROP-CUTTING SURVEY EXECUTED BY ACRES INTERNATIONAL ON VAKANERI SCHEME IN MAHA 1979/1980

Crop Cut No.	Tract	Farmer	Holding Size (acres)	Soil Series	Cultivar	Land Prepara-tion	Application of Inputs: Fertili-zers	Weedi-cides	Pesti-cides	Yield (t/ha)
1	Kalwalai	P. Wairamuttu	3	Bo	H4	BP	<X	0	0	2.82
2	Vahulawalai	S.M. Hajear	20	Up	H4	TP	<X	X	X	2.04
3	Paddiyadevely	S.M. Mustapa	11	Be	H4	TP	<X	X	X	2.95
4	Paddiyadevely	M. Adambawa	10	O	H4	TP	<X	X	X	3.26
5	Paruthichenai	A. Sarivu Hajear	5	M	H	TP	<X	0	0	2.77
6	Tharanai Nooracre	M.M. Mohideen	20	M	BG94-2	TP	X	X	X	3.67
7	Sembayadi	A.L. Velachi	5	Ma	H4	BP	<X	X	X	2.54
8	Sembayadi	A.P.E.L. Hajear	16	Ku	BG94-1	TP	X	X	X	3.49
9	Paddimadu	A.I. Lebbai	33	Up	H4	TP	<X	X	X	2.95
10	Paruthichenai	K. Welmurugu	13	M	H4	TP	X	X	X	2.85
11	Adam Padiwaddawan	M.M. Patumma	9.5	Ku	BG94-1	TP	X	0	0	2.82
12	Makulanai	P. Laffer	-	M	H4	-	-	-	-	3.02
13	Kalwalai	T. Alagaratnam	7	Up	BG94-1	TP	X	X	X	2.29
14	Mulliwaddawan	C. Subramanium	3	Up	H4	BP	<X	0	X	1.42
15	Vaddi Paddamadu	M. Tharmeshwaram	3	G	H4	BP	<X	0	0	1.50
16	Vaddipoddamadu	T. Sinnakandu	3.5	Up	H4	TP	<X	0	X	3.16
17	Vaddipoddamadu	K. Vallipillai	6	Up	H4	TP	X	X	X	3.74
18	Murukanthiru	S. Valliamma	4	M	Tradi-tional	TP	<X	0	X	2.51
19	Odduwali	A. Aiuwath	16	Up	H4	TP	<X	X	X	2.41
20	Kattukattu	T. Selvanayagam	7.5	M	H4	TP	<X	X	X	2.72
21	Mahilayadi	A. Thangarasah	10	Ku	H4	TP	<X	X	X	2.89
22	Vaddipoddamadu	P. Yogarajah	5	Ar	BG34-8	TP	X	X	X	4.04
23	Vaddipoddamadu	S. Nagamani	3	Pa	Tradi-tional	BP	0	0	0	1.79
24	Paruthichenai	N.M. Ahamed	15	Ma	BG94-1		X	X	X	4.17

Note: Yields are expressed for a moisture content of approximately 15 percent. Samples were dried to this moisture content and carefully winnowed, to bring them to quality standards which would be acceptable to the Paddy Marketing Board.

Symbols:
- B = Broadcast
- T = Transplanted
- BP = Buffalo ploughed
- TP = Tractor ploughed
- X = Applied at or above recommended rate
- <X = Application below recommended rate
- 0 = Not applied.

The Pimburettewa Scheme

The fields in the Pimburettewa Scheme which were surveyed in both seasons provide a comparison of Yala and Maha yields. Differences between correlated crop cuts for 16 fields where the soils are classified as suitable for lowland paddy cultivation are presented in Table E-3.14. This comparison indicates that, in general, higher yields are achieved in the Maha season. The value of 't' (the ratio of the mean difference to its standard error) is 2.71, which is statistically significant at the 5 percent level.

In theory, if no yield constraints existed, Yala yields would have been higher by reason of the greater sunlight intensity in that season. Factors that contributed to the significant superiority of Maha yields include

- the relative absence of water stress in that season

- the predominance of longer-duration cultivars and of the practice of transplanting, which the greater availability of water permitted. The use of short- and long-duration cultivars was about equal in Maha 1980; the percentage of Pimburettewa fields carrying early and late cultivars, and broadcast and transplanted in the two seasons are as shown below.

Cultivars Planted	Yala		Maha	
	Broadcast (percent)	Transplanted (percent)	Broadcast (percent)	Transplanted (percent)
90-day cultivars	47	53	37	63
120/135-day cultivars	nil	nil	12	88

TABLE-E-3.14

COMPARISON OF YALA 1979 AND MAHA 1979/1980 YIELDS IN PIMBURETTEWA SCHEME

Location	Soil Series	Yala 1979 Cultivar	Yala 1979 Yield (t/ha)	Maha 1979/1980 Cultivar	Maha 1979/1980 Yield[2] (t/ha)	Difference Maha - Yala (t/ha)
1	Ma	BG34-8	3.16	BG11-11	3.39	0.23
2	Ma	BG34-8	3.84	BG34-8	4.29	0.45
3	G	BG34-8	3.84[3]	BG34-8	3.94[3]	0.10
4	G	BG34-8	4.51[3]	BG34-8	3.04[3]	-1.47
5	Pa	BG34-8	3.19	BG11-11	7.03	3.84
6	A	BG34-8	3.39	BG11-11	7.69	4.30
7	G	BG34-8	2.71[3]	BG11-11	4.28[3]	1.57
8	Pa	BG34-8	5.53	BG11-11	5.72	0.19
9	A	BG34-8	5.64	BG11-11	5.48	-0.16
10	G	BG34-8	4.97[3]	BG34-8	5.20[3]	0.23
11	Mo	BG34-8	4.29	BG11-11	6.09	1.80
12	Pa	BG34-8	7.22	BG11-11	7.77	0.55
13	A	BG34-8	5.33	BG11-11	7.33	2.00
14	Ul	BG34-8	5.33	BG90-2	5.14	-0.19
15	Pa	BG34-8	4.06	BG11-11	6.75	2.69
16	Pa	BG34-8	4.29	BG34-8	4.94	0.65

Notes:

[1]Crop cuts Nos. 1 to 17 are taken from the same farms as in Tables E-3.11, E-3.12 and E-3.14.
[2]Uncorrected for moisture content.
[3]These plots are on the Galwewa Series, which is not recommended for development with the project.
[4]Statistics: standard error of difference = $\pm$ 0.3867
calculated value of 't' = 2.71
5 percent point of 't' (15 DF) = 2.131

Table E-3.15 presents yields relating to land classes in the Pimburettewa Scheme. For purposes of the statistical analysis, the soil series have been grouped into the three basic lowland classes (1R, 2R and 6R) which are recognized in this feasibility study (Annex B). Only two of these land classes - 1R and 2R - are recommended for lowland paddy cultivation under the project.

The "t tests" performed on the data in Table E-3.15 indicate that the mean yield obtained on Class 1R is significantly higher than that on Class 6R. Yields obtained on classes 1R and 2R do not differ significantly from each other, neither do those obtained on classes 2R and 6R.

The mean yield of 3.75 tonnes/ha on the soils which fall into Class $6R_s$* indicates that even this soil type can produce a reasonable paddy yield, although all farmers surveyed in this land class reported difficulties with water management and weed control. Excessive water use was evident from the measures employed by the farmers to obtain more water than their neighbors. These measures usually involve physical damage to irrigation structures to ensure a continuous water supply.

Land classes 1R and 2R gave high and comparable yields: mean yields on 1R and 2R were 5.43 and 5.02 tonnes/ha respectively. The results highlight the fact that when the adequacy of the water supply ensures both the elimination of drought stress in critical phases of crop development and the attainment of redox-potential regimes optimal for nutrient release, differences in rice yields between land classes tend to narrow.

*The Galwewa Series of the NCB's was the only soil series in this category.

TABLE E-3.15

PADDY YIELDS ON LAND CLASSES ON
PIMBURETTEWA SCHEME IN MAHA 1979/1980
(tonnes/ha)

Land Classes						
1R			2R			6R
RBE	LHG	OAL	NCB	LHG	OAL	NCB
4.14 Aa*	6.92 D	5.09 M	4.74 Bo	4.04 Ma	4.61 Up	3.65 G
3.59 Aa	6.33 K	4.74 M	6.94 Bo	4.56 Ma	5.36 Up	2.76 G
7.11 Aa	3.99 K	5.33 M		2.76 Ma		4.56 G
4.96 Aa	3.07 K	5.52 M		7.13 Ma		4.04 G
6.73 Aa	5.38 K	5.44 M				
4.76 Aa	6.22 K	3.64 M				
6.14 Aa	7.43 K					
5.20 Aa						
3.80 Aa						
4.65 Pa						
4.78 Pa						
3.93 Pa						
6.47 Pa						
5.44 Pa						
6.95 Pa						
6.29 Pa						
6.28 Pa						
7.35 Pa						
6.04 Pa						
Mean:5.51	Mean:5.62	Mean:4.96	Mean:5.84	Mean:4.62	Mean:4.99	Mean:3.75
	Mean:5.43			Mean:5.02		Mean:3.75

Statistical Analysis

Land class comparison	1Rvs2R	1Rvs6R	2Rvs6R	1R+2Rvs6R
Difference between mean yields	0.411	1.676	1.265	1.620
Pooled standard error for difference	$\pm$0.495	$\pm$0.620	$\pm$0.787	$\pm$0.6365
Calculated value for 't'	0.830	2.703	1.610	2.545
5 percent point of 't'	2.021(38DF)	2.042(34DF)	2.228(10DF)	2.021(42DF)

*Soil Series

Table E-3.16 presents a comparison of the performance of the 90-day cultivar BG 34-8 under broadcast and transplanted conditions in Maha on the 1R and 2R soils. The mean yields of the broadcast and transplanted fields were 4.09 tonnes/ha and 4.99 tonnes/ha respectively - the 't' function for this comparison falls short of significance although it is likely that other factors impinged on the result and thus firm conclusions cannot be drawn. Table E-3.16 also indicates that the yield under transplanted conditions of the longer-duration cultivar BG 11-11 was 6.07 tonnes/ha. Data on the performance of BG 11-11 under broadcast conditions were not available as 120/135-day cultivars are invariably transplanted in Maha due to their superior yield response when transplanted.

Under conditions of unlimited water availability, the choice of cultivar for Yala would be BG 11-11 or the comparable 120/135-day strain. However, under the project, the limiting factor in terms of agriculture production will be water availability in the Yala season. Since the short-duration cultivar BG 34-8 uses significantly less water in Yala than the longer duration cultivar (see Table E-5.5), it is recommended for cultivation in that season. It also uses less water when transplanted, and this planting method is recommended under the project.

The Vakaneri Scheme

Many of the contrasts between the Pimburettewa and Vakaneri Schemes in cultivation standards and practices, choice of cultivars, and ultimate yields derive directly or implicitly from the higher incidence of water stress in the latter scheme. Water stress and the expectation of water shortages obstruct weed control, the practice of transplanting, and the choice of semidwarf cultivars like the recent BG issues.

TABLE E-3.16

BROADCAST AND TRANSPLANTED YIELDS ON PIMBURETTEWA SCHEME IN MAHA 1979/1980
(tonnes/ha)

Cultivar BG 34-8 Broadcast	Cultivar BG 34-8 Transplanted	Cultivar BG 11-11 Transplanted
		6.47
		7.11
3.99	6.43	5.44
4.78	4.65	4.96
3.93	6.33	5.52
4.14	5.09	6.95
3.59	4.74	6.73
	4.56	6.29
	3.07	5.38
	4.74	5.44
	5.33	6.94
		7.13
		7.43
		3.64
		4.76
		6.22
		6.14
		6.28
		7.35
		5.20
Mean: 4.09	Mean: 4.99	Mean: 6.07

Statistical Analysis

	Broadcast vs Transplanted (Cultivar 34-8)	BG 34-8 vs BG 11-11 (Transplanted)
Difference between mean yields	0.90	1.08
Pooled standard error for difference	±0.480	±0.403
Calculated value of 't'	1.900	2.669
5 percent point of 't'	(12DF) 2.120	(27DF) 2.052

Table E-3.17 presents the survey yield results for the Vakaneri Scheme in Maha 1979/80. The calculated 't' value indicates the significant superiority at the 5 percent level of the 1971 to 1975 Batalagoda releases (BG 34-8, BG 94-1, and BG 94-2) to the 1958 Batalagoda release (H4). However, the use of the earlier releases dominates in contrast to the Pimburettewa Scheme where the recent issues, BG 34-8 and BG 11-11, are most prevalent. This again relates to water availability as when water stress presents problems with weed infestation, farmers tend to prefer tall varieties, hence the choice of H4.*

Other factors also account for differences between the two schemes. The larger holding size in the Vakaneri Scheme (a mean of 4.0 ± 0.62 ha as against a uniform extent of 1.2 ha under the Pimburettewa Scheme) encourages the use of heavy machinery: 75 percent of the Vakaneri farmers prepare their paddy land with tractors. Under the Pimburettewa Scheme, land preparation is almost completely by animal power.

Paddy land in the Vakaneri Scheme is largely owned by affluent, absentee farmers and the area suffers from problems of labor scarcity. This, combined with the expectation of water stress, discourages transplanting on the Vakaneri Scheme.** In contrast, 77 percent of the Pimburettewa farmers transplanted their paddy.

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* The culm heights of H4, BG 34-8, BG 94-1, and BG 94-2 are 113 cm, 63 cm, and 67 cm respectively.

**No transplanted fields were found in the Maha 1980 survey. Expectation of lower yields due to water stress appears to discourage transplanting because farmers try to minimize input costs (principally labor) under these circumstances.

TABLE E-3.17

YIELDS OF RICE CULTIVARS ON
VAKANERI SCHEME IN MAHA 1979/1980

Rice Cultivars

1958 Batalagoda Release H4	1971 - 1975 Batalagoda Releases BG 34-8, BG 94-1, BG 94-2
2.82	3.67
2.04	3.49
2.95	2.82
3.26	2.29
2.77	4.04
2.54	4.17
2.95	
2.85	
3.02	
1.42	
1.50	
3.16	
3.74	
2.41	
2.72	
2.89	
Mean: 2.69	Mean: 3.41

Statistical Analysis

Difference in Mean Yields	0.72
Pooled standard error of difference	±0.3075
Calculated value of 't'	2.341
5 percent point of 't' (20DF)	2.086

There are sharp contrasts in soil categories between the Pimburettewa and Vakaneri schemes. In the Vakaneri Scheme, RBE soils are relatively rare, whereas Old Alluvial soils are extensive. However, these differences in soil categories would have contributed only marginally to the yield contrasts between the two schemes.

The timing of initial cultivation in the two schemes is also a factor. Pimburettewa is a relatively recent scheme - settlement of farmers was completed only in 1976 - and would show much less exhaustion of soil nutrients than Vakaneri. Nevertheless, fertilizer use is ubiquitous in both schemes although appreciable numbers of farmers apply it at rates which are below recommended levels. Of the farmers surveyed, 36 percent in the Pimburettewa Scheme and 58 percent in the Vakaneri Scheme applied fertilizer at low rates.

3.3 - Chena Cultivation

3.3.1 - Chena Area and Cultural Practices

Chena (slash and burn) agriculture is the oldest form of rainfed cultivation in the Dry Zone. Although in some areas it is the only form of agriculture practised, it is more often practised in association with paddy cultivation under a tank or upland/rainfed paddy. Within the project area, chena cultivation is also practised on

- Virgin Jungle - maximum cropping period of 3 yr

- Scrub Jungle (10- to 15-yr old chena) - cropping period of 2 yr

- Short Cycle Chena - fallow period of 2 to 3 yr. If grasses dominate the fallow vegetation, livestock grazing may be practiced as a "Maha crop" in association with the grazing of the Villus in the river floodplains during Yala - cropping period of 2 yr

- "Permanent" Cultivation - subsistence food crops and cash crops in Maha; fallow or very short duration crops (60 days) in Yala.

Related to the above-mentioned chena types, different cropping patterns are distinguishable as follows.

- A mixture of two or more crops, broadcast, e.g., kurakkan and mustard; cassava, maize and cucurbits; or bananas and papaw. Planting starts in Maha with the onset of the rains and continues as far as possible into the Yala (Type 1 and 2 chena)

- Single blocks or interplanting with a total of 5 to 6 crops in one field, for instance, chillies, cowpeas, maize, tomato, and ladies' finger (Type 2 and 3 chena).

- A great variety of crops for subsistence and for the local markets may be grown. In this case, there is some specialization in cash crops like tobacco, chillies, or soybean, for which fertilizers might be used. During Yala a short duration crop like sesame or pulses is sometimes also grown. The success of the latter depends on adequate rainfall (Type 4 chena).

- When the permanently cultivated land becomes a homestead (even of 1 to 2 ha) more perennial crops are grown, such as coconut, fruit trees, and hedges, and different types of useful trees and plants for fodder, firewood, medicinal herbs, etc. For example, in a homestead plot of about 1/2 ha on a well drained RBE in the village of Wadamunne the following crops were observed on September 27, 1979: maize, cassava, groundnuts, sweet potato, sugar cane, chillies, banana, papaw, sweet melon, eggplant, passion fruit, thurdhal, Sesbania grandiflora, drumstick, jak, and a hedge of Glyricidia and kapok.

On fertile soils the final stage of chena may be the homestead; on infertile soils it may become man-made "parkland". The natural vegetation, even on the shallow (sandy) soils, is forest and scrub. Bamboo is very rare in the project area. This may be due to the shallowness and subsequent drying of the soils in Yala. As a general purpose plant it may be suitable along river courses and canals.

The total area of land devoted to existing or recent chena cultivation has been estimated from the 1979 aerial photographs to be 32 800 ha. The average chena area per family is estimated to be about 8.3 ha. Assuming a cropping period of 3 yr (because the percentage of the total area in virgin forests is still high), and an average chena cycle of 15 yr (12 yr for regrowth), this implies that the average annual chena area cropped per family amounts to about

$$3/15 \times 8.3 = 1.67 \text{ ha/family.}$$

The calculations are summarized as follows.

Total chena area	32 800 ha
No. of families	3 929
Total chena area per family	8.3 ha
Average chena cycle	3/15
Averaged cropped chena area per family	1.67 ha
Active chena area per year	6 600 ha

3.3.2 - Chena Production Practices

There are two basic chena cultivation practices: cutting and burning of the vegetation (late Yala) and the planting and sowing of the crops. No soil tillage is done in chena Types 1 to 3 except for the direct planting and seeding. Weeding is kept to a minimum but becomes more important with the short cycle fallow or in the second and third cropping year. Cutting of the vegetation is the most labor consuming activity in chena Type 1 and becomes less in Types 2 to 4, while land preparation and weeding activities increase.

Chena Type 4, the permanent cultivation, will need a high amount of land preparation, mostly done by hoe but also by ploughing. Weeding becomes such a problem that it is the limiting factor in this type of cultivation. Without additional farm power or a substantial proportion in perennial crops (on the homestead), the total area that can be handled by an average family of 2.8 man-labor units is about 1 ha, in addition to 1 ha of paddy land. Livestock also becomes more important for farm power, farmyard manure fertilization and additional income in this Type 4 chena.

3.3.3 - Chena Yields and Production

Chena yields depend very much on soil fertility, rainfall, and the crops that are grown. Soil fertility depends on the physical and chemical properties of the soil itself plus the additional humus that is directly related to the type of vegetation on the land before it is brought under cultivation. The humus level is highest in Type 1 chena (from virgin forest) and lowest in Type 4 chena (only Yala fallow). Nevertheless, total fertility can be higher in the latter because of higher basic soil fertility. If for certain crops farmyard manure or chemical fertilizers are applied, good yields can be expected, provided the rainfall is adequate. "Permanent" chena cultivation (Type 4), with a fairly high degree of land preparation before planting, requires erosion control as an important part of cultivation practice. The simplest form is the preparation of low ridges along the contours that can be planted with a crop. Planting numerous perennial crops that leave the soil undisturbed is another method of control. Where no erosion control measures are taken, the tilled soil will erode very quickly, even on slopes of less than 2 percent.

No more than an estimate of the yield of the average chena homestead can be made here. Although a Yala crop is also sown, this very often is a total failure. Table E-3.18 provides some indication of the extent of chena cultivation in the Maha and Yala seasons for the major chena crops in Polonnaruwa District for the year 1976/77. Some of this is in the System B project area. Table E-3.19 presents a summary of the estimated total cultivated area in the project area, according to official DCS statistics.

It is estimated that of the total production of highland crops, one-third is grown on homesteads and two-thirds on chena areas. It is almost impossible to produce exact figures on the value of the total production of chena cultivation (including homesteads) because, as mentioned earlier, the cropping pattern is very much a mixed system with numerous crops on the same field. An average for a certain crop mix must be taken in order to estimate the potential value of chena cultivation. Table E-3.20 presents a hypothetical calculation for a mixture of 6 crops, each representing a group of crops that is normally found on chena lands in the area. The calculation of the gross value of the production from chena and the homestead is an estimated average for the Maha and Yala season in cases where the crop is grown in both seasons.

TABLE E-3.18

TOTAL AREA OF HIGHLAND CROPS,[1] POLONNARUWA DISTRICT, 1976/77

Crop	Maha 1976/77 ha	Maha 1976/77 Percent	Yala 1977 ha	Yala 1977 Percent of Maha	Average Yield (kg/ha)[2] Maha	Average Yield (kg/ha)[2] Yala
Maize	731	16.4	258	5.4	800	500
Green gram	196	4.1	257	5.4	650	550
Cow pea	444	9.2	311	6.6	850	700
Gingelly	427	8.8	281	5.9	800	650
Groundnuts	172	3.5	412	8.7	900	500
Cassava (fresh, 6 months)	1 335	28.1	1 271	26.9	6 000	
Sweet potato	131	2.7	153	3.2	7 000	
Chillies (dried	856	17.9	1445	30.6	700	400
Mustard	62	1.2	15	0.3	500	
Red onion	72	1.4	84	1.8	8 100	5 400
Kurakkan	372	7.8	95	2.0	800	
TOTALS	4 719	100.0	4 582	96.8		

Notes:

[1]Cropped area from Polonnaruwa District statistics, 1979.

[2]Estimated average yield obtained from secondary sources and personal information from farmers and officials.

TABLE E-3.19

RAINFED UPLAND CROPPED AREA IN SYSTEM B
Maha 1977/1978 (ha)

Crop	Polonnaruwa District*	Batticaloa District*	Total
Cereals			
Maize	134	344	478
Millet	17	15	32
Pulses	22	17	39
Oil Seeds			
Sesame	34	6	40
Groundnuts	10	20	30
Root Crops			
Cassava	114	264	378
Sweet potato	25	16	41
Vegetables			
Chillies and onions	67	61	128
Perennials	80	520	600
Others	94	43	137
TOTALS	597	1 306	1 903

*Reference to the Polonnaruwa and Batticaloa Districts means those parts within System B.

Source: Department of Census and Statistics

TABLE E-3.20

POTENTIAL ANNUAL GROSS VALUE PER HECTARE OF CHENA AND HOMESTEAD PRODUCTION

Crop	Production (kg/ha)	Value* (Rs/kg)	Gross Value* RS/ha/crop)	Cropping Intensity	Gross Value* (per ha/yr)
Maize	700	2.00	1 400)		2 100
Cowpea	700	5.25	3 675)	1.50	5 512
Chilli	450	19.00	8 550)		12 825
Vegetables	8 000	1.00	8 000)		12 000
Cassava	10 000	0.50	5 000)	1.00	5 000
Banana	1 000 (bunches)	11.00 (per bunch)	11 000)		11 000
TOTAL					48 437
Average Gross Value per ha/yr					Rs 8 072*

*Actual return to the farmer will be much less, due to the lack of marketing infrastructure, difficulty of access, etc.

Chena production is generally a very labor-intensive activity. About 160 man-days/yr are required for land clearing, planting, some weeding and harvesting. Seeds and planting material are sometimes purchased from neighbors, but generally do not cost more than Rs 50/ha. No cash is spent on any other inputs like fertilizer and crop production chemicals, a practice which would reduce the risk of failure if the rainfall were inadequate.

Generally speaking, average yields on the homestead will be higher than on the chena because of slightly more care and a greater amount of natural fertilization.

3.3.4 - Chena Production With the Project

The loss of chena cultivation which will result from implementation of the project has not been taken as an economic loss attributable to the project for the following reasons.

- The destruction of forest and soil resources which results from chena cultivation renders negative the overall impact of this type of farming.

- Significant areas will remain available for chena cultivation.

- Improved access, input availability and markets which will accompany the project will improve farm gate prices for the remaining farmers.

3.4 - Production Support

Although offical government support for annual crop agriculture theoretically covers all crops under different farming systems, in reality it is generally limited to lowland paddy cultivation. An exception is the research conducted at the Agricultural Research Station for the Dry Zone in Maha Illuppallama where all major crops in the Dry Zone are included in the research program. At Maha Illuppallama, attention is also given to cropping patterns and farm and water management. But when it comes to practical support programs to the farmer at the divisional and even more so at the village level, all programs concerning input supply, credit, extension, marketing, processing, etc. are generally restricted to paddy production. Although something may be done for other crops (generally by specialized crop rotations) it is more the exception than the rule. Support for crops other than paddy is almost completely provided by private enterprise (e.g. Ceylon Tobacco Company). Thus, the small farmer is often reluctant to grow these crops, which he cannot use himself, have unsure markets, and have high cash input requirements.

3.4.1 - Farm Inputs and Marketing

The supply of agricultural inputs is directed primarily at paddy cultivation. This is certainly the case in the project area where paddy is the main crop and the only crop that enters the national market in large quantities. The organization which is generally responsible for farm supplies, production credit, and paddy marketing at the local level is the Multipurpose Cooperative Society (MPCS).

The functions of the MPCS are

- to supply seed, fertilizer, chemicals and sometimes small implements to farm members.

- to channel cultivation loans for paddy from the Rural Bank to farm members.

- to purchase the paddy at purchasing centers, where, according to fixed quality standards, the paddy is classed into three different grades.

The purchasing is done on behalf of the Paddy Marketing Board (PMB). The PMB provides the cooperatives with a 90-d Marketing Loan for this purpose. A farmer who obtains a Cultivation Loan through the cooperative from the Rural Bank must sell his paddy via the cooperative, where the Cultivation Loan is subtracted, a certain amount paid in cash, and the remainder credited to his account with the cooperative or bank.

The Polonnaruwa District has 9 primary MPCS and about 125 branches. In general, the MPCS and their branches have very limited paddy storage capacity and an insufficient number of depots and warehouses for input supplies. Moreover, they have no facilities to improve the quality of the paddy on behalf of the farmer. Paddy which does not meet the minimum standards (Grade 3) is simply rejected.

Farmer participation in the MPCS is also limited because

- cooperative services are only available to bona-fide members

- membership is restricted to farmers who have legal title to land

- credit defaulters cannot reapply for cultivation loans.

Thus, all farmers who either do not qualify as bona-fide MPCS members or produce crops other than paddy generally have to rely on private traders for farm inputs, short-term credit, and product marketing. Private traders are frequently middlemen or agents of a corporation.

In the case of paddy, private traders also have a share of the official paddy trade controlled by the Paddy Marketing Board. These are the appointed private agents who sell the paddy to the PMB on the same terms as the cooperatives. The PMB pays them a commission of Rs 3.52/100 kg paddy on top of the guaranteed (minimum) price of Rs. 1.91/kg for Grade 1 and Rs. 1.78/kg for Grade 2. (This guaranteed minimum price is equal to about Rs 40/bushel.)

3.4.2 - Extension Services

The extension service in the project area is organized as elsewhere in the country. The two districts which cover the area almost completely are Polonnaruwa and Batticaloa.

At the district level, the extension organization is headed by the Agricultural Extension Office. The extension organization below the district level is the Agricultural Production Centre (APC).

Agricultural Extension Officer

↓

Agricultural Instructors (2)

APC ↓

Village Extension Workers (12)

↓

Farmers
(2,000)

There are nine APC's in Polonnaruwa, two of which are in the project area (Manampitiya and Pimburettewa). The APC is staffed by two agricultural instructors and an average of six village extension workers (Krushikarma Viyapti Sevakas - KVS) per agricultural instructor. The area served by one APC is about 3,200 ha under cultivation or some 2,000 farmers.

The Batticaloa District has an APC at Valaichchenai covering the remainder of System B.

Virtually every possible method of conveying information to the farmer has been employed. In descending order of importance, these include

- extension personnel visiting farmers
- farmer neighbors
- training classes
- demonstration plots
- advisory leaflets
- visits by farmer to extension center
- radio programs
- agricultural film shows
- newspaper articles.

As a general method of approaching the farmers, the extension services have adopted the "training and visit" method which has become an extension method in many districts of the country.

Nevertheless, the extension service mainly focuses on paddy cultivation. This limits its role in the general agricultural development process in the project area.

3.5 - Relevant Experience in Surrounding Area

Agriculture in the project area, as detailed above, does not basically differ from other Dry Zone areas. The general pattern for the whole of the Dry Zone is

- Old System - Purana villages, under minor tanks
- Recent Colonization Schemes, under major tanks.

Both are associated with chena cultivation.

3.5.1 - The Old System

The old system is characterized by almost full employment in agriculture in which the following activities can be distinguished

- chena cultivation in the highlands
- paddy cultivation under tank schemes
- upland paddy cultivation on imperfectly drained uplands
- some livestock raising, principally cows or buffalo.

In this system, the main emphasis is often given to chena cultivation because paddy production is still risky. Although paddy cultivation is the main source of staple food, chena crops are also important as additional subsistence food crops. Very often chena is the main source of food and income. Under old minor tanks (about 1 ha/farmer), only one paddy crop in the Maha or late Maha is generally possible because the common practice is to sow only when sufficient irrigation water has been stored in the tank. Transplanting is limited because of the unreliability of the water supply until irrigation from the tank is possible. Yield can be expected to vary directly with the amount and timing of irrigation water application. In any case, fertilizer and crop protection chemicals may be used. The paddy fields lie fallow during the remainder of the year.

3.5.2 - Recent Colonization Schemes

Recent colonization schemes (started since 1900, but the majority only after 1930) are of two types

- large irrigation schemes, with a supplementary water supply from outside the catchment area, which assures irrigation throughout the year

- small irrigation schemes with a water supply from the local catchment area only, which does not assure irrigation throughout the year.

In the project area, only small colonization schemes are found. These are Pimburettewa, Wadamunne, Vakaneri and Punanai. The nearest large colonization scheme is Parakrama Samudra, near the town of Polonnaruwa. In the earliest schemes, the settlers were assigned 5 acres (2 ha) of paddy land and 3 acres (1.2 ha) of highland for permanent cropping. This gradually decreased (with population pressures) to 3 acres (1.2 ha) in total, generally 2.5 acres for paddy and 1/2 acre for a homestead (e.g., System H).

Paddy cultivation under these schemes has become the main activity and is generally practised in an intensive way with a rather high input level and yields ranging from 2.8 to 6.5 tonnes (see Section 3.2.3). If there is no paddy in Yala (in the small schemes) the land lies fallow and is grazed by cattle. With better water management, better cultivation practices are required. In these schemes, therefore, a higher degree of mechanization is required to achieve timely planting. More transplanting is also done where a reliable water supply is available. As a general rule, the yield of a broadcast crop is 15 percent less than a transplanted crop under similar conditions (soil, water, chemicals, variety), primarily because of less weed control.

Although paddy cultivation has become the major agricultural activity under recent colonization schemes, chena cultivation is still attractive and often gets more attention than the paddy because of tradition, farm power problems, home needs, and last but not least, low cash input requirements.

4 - PROJECTED SITUATION WITHOUT THE PROJECT

4.1 - Paddy Cultivation

The total area that is now under tank irrigation has almost reached the maximum irrigable from the existing tanks. There is no tank scheme, even Pimburettewa and Vakaneri, that can irrigate the full area under command during Yala. The cropping intensity, therefore, will remain low.

All tanks in the project area at the moment and in the foreseeable future without the project will only be filled from local catchments. This means that the water from the Maha rains that is stored in the tank at the end of the Maha season is the only available water for the Yala crop. It is unlikely that the cropping intensity can be increased substantially without supplementary water from outside the area. Moreover, as long as water is the limiting factor no substantial increase in production can be obtained by increasing the use of other inputs.

Projected cropped areas and yields for the "without the Project" situation are summarized in Table E-4.1.

4.2 - Chena Cultivation

The chena area could still be doubled if all the virgin forest is depleted. The final stage will be that practically all upland soils will erode to a stage where soil fertility has become so low that no more cropping is possible and the land is totally useless. An alternative would be that as soon as the chena cycle (equals the fallow period) has become so short that no natural recovery of soil fertility is

TABLE E-4.1

PROJECTED PADDY PRODUCTION WITHOUT THE PROJECT

Area	Net Irrigable Area (ha)[1] Maha	Yala	Yields Maha/Yala/(t/ha)
Pimburettewa	1 260	1 160	4.6/4.6[2]
Vakaneri/ Punanai	3 530	880	2.8/2.8[3]
Small tanks	2 700	540	3.2/2.4[4]
Rainfed	4 000	-	3.2/0[5]
Totals	11 490	2 580	

Notes:

[1]Areas estimated by referring to the map of present land use and official statistics.
[2]Yield estimates from crop-cutting experiments in Yala 1979 and Maha 1979/1980 indicate that yields of about 4 t/ha and over 5 t/ha respectively are now attained. However, the yield of 4.6 t/ha shown in the table was adopted to be consistent with "with Project" assumptions.
[3]Latest 5-yr "mean" Batticaloa District - major schemes (DCS).
[4]Latest 5-yr "mean" Polonnaruwa + Batticaloa Districts - minor schemes (DCS).
[5]Latest 5-yr "mean" Polonnaruwa + Batticaloa Districts - rainfed (DCS).

possible, the land should immediately be brought into a state where no further decline in soil fertility occurs. This would only be possible with a high investment in erosion control and/or a cropping pattern that maintains soil fertility. It is not very likely that such measures will be taken for land that provides only one crop in the Maha season. Irrigation would be necessary to improve the Maha crop and make the Yala crop reliable.

In summary, without the Maduru Oya project, the area under chena cultivation could possibly double. After this point, there would be a decline in production due to declining soil fertility with shorter fallow periods, until very little production was possible. This would involve the total depletion of the forest area, which would be ecologically unacceptable, even if proper measures were taken to maintain soil fertility for permanent cultivation. Very few production improvements can be expected because of the total dependence on an unreliable water supply (rainfall). This will continue to cause varying unpredictable yields in Maha and crop failures in Yala. Thus the continued deterioration of forest and soil resources can be expected without the Project. The rate of deterioration will depend on population pressures from the surrounding area.

5 - POTENTIAL DEVELOPMENT WITH THE PROJECT

5.1 - Lowlands

5.1.1 - Land Classes and Cropping Potential

Annex B presents extensive data covering the subject of "Soils and Land Classification". The following paragraphs summarize the aspects related to agriculture.

Soil and topographical surveys conducted during the present feasibility study indicate the availability of a net irrigable area of 34 330 ha* suitable for double-cropping in paddy. This figure (which excludes the 4,780 ha under the Pimburettewa and Vakaneri Schemes) considerably exceeds earlier expectations. By contrast, the net area of irrigable uplands available for upland cropping is only 1,800 ha.* Clearly, the Maduru Oya project should be planned and operated primarily as a paddy project. Table E-5.1 subdivides the total of 60 400 ha of potential paddy soils surveyed in the project area into soil categories and land classes.

The recent alluvials are some of the richest paddy soils in Sri Lanka. The Timbiri Aru and Odigar Villu Series, with clay contents of 20 percent and 62 percent and cation exchange capacities of 18 and 52 me/100 g respectively, cover 8,300 ha of the area and comprise about 15 percent of the potential paddy area. The clay fraction of, at least, the Odigar Villu Series is clearly montmorillonitic.

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*After deducting areas required for reserves, irrigation infrastructure, and to achieve a water balance. These areas are, therefore, the paddy lands that can be allocated to farmers.

**It is anticipated that 0.3 ha irrigated homestead plots will be allocated to each upland smallholder, adjacent to 31.5 ha farm area. The net area to be cropped under non-homestead conditions will, therefore, be 1,500 ha.

TABLE E-5.1

LOWLANDS: LAND CLASSES AND SOIL CATEGORIES SUITABLE FOR DOUBLE-CROPPED PADDY

Great Soil Group	Soil Series	Land Classes	Extent		CEC me/100 g		Exchangeable Potassium
			ha	Percent of Total	0-30 cm	30-60 cm	
Old Alluvials	Moogamana-Fla	$1R + 2R_t$	11 090	20.6	9.4-13.9	10.4-11.1	Very low
	Ulpothawewa	$2R_s$	9 860	18.4	3.9-8.4	7.2-8.1	Low
Recent Alluvials	Timbiri Aru	$1R + 2R_t$	5 800	10.8	18.3	17.3	High
	Odigar Villu	1R	2 480	4.6	52.2	37.2	-
Low Humic Gleys	Kuda Oya	$1R + 2R_t$	3 280	6.1	11.1	13.5	-
					3.6	4.6	Very low
Reddish Brown Earths (imperfectly drained)	Alawakumbura	$1R + 2R_t$	4 470	8.3	8.8-11.9	8.9-13.4	Very high
	Padumunda Kulam	$1R + 2R_t$	1 840	3.4	6.0-16.8	7.9-17.3	Medium to very high
	Horaborawewa	$1R + 2R_t$	2 470	4.6	25.2	18.9	Medium to high
Noncalcic Brown Soils (imperfectly drained)	Boattewewa	$2R_s$	11 670	21.7	5.6	7.3	-
Solodized Solonetz	Vakaneri	$2R_s$	520	1.0	3.5	10.9	-
	Pochchakadu	$2R_s$	120	0.3	-	-	-
Miscellaneous		1R + 2R	120	0.2	-	-	-
TOTALS*		1R + 2R	53 720	100.0			

*The Pimburettewa Tank Scheme and the Punanai scheme which have already been developed, are included in the surveyed area. The areas shown above should therefore be taken as indicative of relative proportions only.

The cation exchange capacities of all the lowland series generally exceed 5 me/100 g. The phosphate status is generally satisfactory. Apart from the Recent Alluvials and the imperfectly drained RBE's, the soils tend to be low in exchangeable potassium.

Generally, the yield potential of the lowland soils in System B is relatively high. In the crop-cutting survey executed in Yala 1979 and Maha 1979/80, yields on the soil series classed as "1R" averaged 5.4 t/ha in Maha and 4.4 t/ha in Yala; yields on the soil series assigned a basic land class of "$2R_S$" averaged 5.0 t/ha in Maha and 3.8 t/ha in Yala.

5.1.2 - Rice Agronomy

Field Water Management

Uninterrupted water flow over the cropped area, whatever the peripheral benefits from temperature control, wastes irrigation water and should be stopped. Moreover, fertility losses may result from the leaching of fertilizers and the removal of the finer soil particles.

Two alternative systems of field-water management may be adopted.

- Continuous submergence involving the maintenance of, say, a 5 to 10 cm depth of water on the field from the initiation of flower primordia (24 days before heading) till the completion of grain filling (15 days after heading). The water level will, of course, be lowered for fertilizer topdressings.

- Intermittent irrigation, a system under which the inflow of water is cut off once the field is flooded, and is not resumed until the water has been completely consumed by evapotranspiration, percolation and seepage.

Research results elsewhere in the Dry Zone (Maha Illuppallama) indicate that intermittent irrigation gives lower yields. These yield-depressant effects are likely to be greater on the lighter-textured soils with higher percolation rates. Irrigation methods, through their effects on the redox-potential regimes in soils, can profoundly affect nutrient availability. A rice soil, when submerged, differentiates into a surface oxidized layer, not exceeding a few millimetres, and an underlying reduced mass. Of the various chemical changes that occur in the oxidized layer, the most important nutritionally are

(a) the nitrification of ammonium ions to nitrates

$$NH_4^+ \longrightarrow NO_2^- \longrightarrow NO_3^-$$

(b) the oxidation of ferrous ions to ferric, and the consequent formation of insoluble ferric phosphate

$$Fe^{++} \longrightarrow Fe^{+++}$$

When the nitrates produced in reaction (a) move into the underlying reductive zone, they are either leached out, or denitrified into

$$NO_3^- \longrightarrow NO_2^- \longrightarrow N_2$$

Under optimal water management, the nitrification - denitrification losses are appreciable only in the early stages of the paddy crop, and are eliminated by direct placement of ammonium nitrogen in the reductive zone.

Under intermittent irrigation, if the intervals between water issues are protracted, a considerable depth of soil can become oxidative, and this rise in redox potential would lead to low nutrient availability, consequent on (a) nitrification - denitrification losses, and (b) the conversion of ferrous phosphate to insoluble ferric phosphate.

Clearly, field-water management should be designed to maintain a redox potential regime below the limits critical for chemical changes (a) and (b): nitrogen loss would be eliminated and phosphate would be maintained in available form if the redox potential (Eh_7) is kept below about 130 mV. Very low redox potentials which lead to sulfide and other toxicities should, however, be avoided.

The above-mentioned objections to intermittent irrigation should not prejudice the practice of mid-season drainage in the period preceding flower initiation, nor the application of water on a rotational basis so long as prolonged dry periods are not permitted.

Growth and Development in Relation to Water Stress

The the sowing-to-harvest duration may be divided broadly into 3 phases

- the vegetative phase (sowing-panicle initiation)
- the reproductive phase (panicle initiation - heading)
- the ripening phase (heading to harvest).

A diagram illustrating the duration of each of these three phases is given in Figure E-4.

The reproductive phase (approximately 24 days) and the ripening phase (30 to 35 days) are roughly the same for all varieties. The wide variation in the total sowing-harvest duration is determined by the vegetative phase.

In regard to water needs, the reproductive phase and the early ripening phase are critical: if maximum yields are to be secured, the period of nearly 40 days extending from the commencement of the reproductive phase (about 24 days before heading) to the completion of grain-filling (15 days after heading) should be free from water stress. Particularly crucial is the 27-day interval from reduction division (12 days before heading) to complete grain filling; the occurrence of water stress during this interval will markedly depress grain yields. The simplest means of ensuring freedom from water stress is uninterrupted submergence during the vulnerable period.

Broadcast paddy is relatively indifferent to water stress in the vegetative phase. During this period, paddy could be treated as an upland crop. The position is very different with transplanted paddy. Nurseries should be inundated: seedlings raised in upland nurseries, by reason of their low silica uptake, succumb to blast (Pyriculuana oryzae). Moreover, shallow inundation should commence on the fourth day after transplanting, water depth should be raised progressively to about 10 cm and should continue until the transplanted seedlings are well established.

The Effect of Inundation on Nutrient Availability

Submergence of paddy fields, through its depressant effect on redox potentials, promotes nutrient availability and provides the most cogent argument for growing paddy as a wetland crop. The fall in redox potentials (a) ensures the stability of ammonium nitrogen in the soils, and (b) induces the reduction of insoluble ferric phosphate to ferrous phosphate; the latter, by reason of its solubility, then becomes available.

Low nutrient availability is the main reason for excluding upland paddy from the recommended cropping pattern for

System B. If paddy growing on irrigable land is desired, fields should be bunded so that some measure of submergence is ensured. This is already the practice in existing rainfed areas in System B.

Water management techniques for weed control are well known and need no emphasis.

Seed

The supply of adequate quantities of high-quality seed, not only for paddy, but for all crops grown in System B, is crucial to the successful implementation of the proposed agricultural program. The breeders' achievements at Batalogoda can make a marked impact on paddy yields in System B only if supported by an efficient seed production and certification scheme.

The project's total requirements in certified seed paddy will reach some 1,800 tonnes. To produce this quantity of seed, a seed-production area of about 400 ha will be needed. This area could be distributed among approved private seed farmers who would receive their foundation or registered seed through the Central Seed Production Division of the Department of Agriculture.

A small seed-testing laboratory whose staff will assume responsibility for field inspection and roguing and for germination and purity tests should be established in System B, preferably on the Experimental Demonstration Farm (see Section 7).

The laboratory's conformity to the rules of the International Seed Testing Association (ISTA) is desirable. Minimum standards stipulated are

- purity 98 percent
- germination 80 percent
- weed seeds 0.05 percent.

Rice Breeding

The universal use of improved varieties along with the appropriate package of inputs is a prime objective. In Sri Lanka, achievements in rice breeding during the last three decades have been spectacular: some of the recently bred cultivars have a yield potential of over 8 tonnes of paddy per hectare. The cultivars specifically recommended for System B are BG 11-11 and BG 90-2 (4 to 4-1/2 months) in Maha and BG 34-8 (3 to 3-1/2 months) in Yala.

When the Maduru Oya and other Mahaweli projects reach projected production levels, Sri Lanka is expected to have an exportable surplus of paddy. Breeding for the export market must, therefore, be accelerated. Low head-rice recovery and chalkiness of the grain are conspicuous defects in local rices. A hybridization program designed to eliminate these defects is being executed at the Central Rice Breeding Station, Batalogoda: selections CICA4 and CICA6 from CIAT (Colombia) and IR 36 and IR 20 from IRRI (Philippines) are used as parents.

Transplanting Versus Broadcasting

The weed control, yield and water use saving* benefits from transplanting are well known. With the adequate water supply

*This is discussed in Section 5.4.2.

that the project will ensure, transplanting can and should completely replace broadcasting in System B. Judicious nursery fertilization will ensure that seedlings are neither chlorotic nor stunted at transplanting time (3 week after sowing).

Fertilizer Use

Aside from water, fertilizers and improved cultivars are the most important components of the input package. Adaptive research in the field of fertilizer use must be emphasized in project activities: production functions should be calculated from the results of fertilizer trials in farmers' fields, and economic optima derived therefrom. The data now available suggest that the following levels are appropriate at present price levels

- nitrogen	100 kg/ha	(Urea - 215 kg/ha)
- P_2O_5	40 kg/ha	(TSP - 75 kg/ha)
- K_2O	30 kg/ha	(muriate of potash)

It is desirable to have a schedule of nitrogen application that restricts vegetative growth, and diverts maximum quantities of the nutrient to grain formation. The following schedule of split applications should achieve that objective.

- Basal dressing, subsurface placed: 5 kg N/ha along with P&K.
- Topdressing
  14 days after transplanting: 15 kg N/ha
  24 days before heading (panicle initiation): 45 kg N/ha
  12 days before heading (reduction division): 15 kg N/ha
  at heading: 20 kg N/ha.

All of the phosphate and part of the potash (67 percent) should be applied basally.

Potash topdressings delay leaf senescence--an effect of crucial importance as 70 percent of the carbohydrate that accumulates in the rice grain derives from post-heading photosynthesis. Of the total quantity of muriate of potash applied, the last 33 percent should be topdressed at heading.

Splitting of nitrogen and potash applications becomes particularly desirable on the light soils of the project area, where leaching losses are predictable.

Responses to nitrogen are expected to be particularly marked in System B: yield increases up to 2 tonnes/ha are likely to follow the application of 100 kg N/ha.

Weed Control

Particularly in the context of the energy crisis, farmers should rely increasingly on transplanting, water use and manual/mechanical operations for weed control. It appears likely that weedicides like propanil will price themselves out of the market. For the immediate future, the following recommendations may be adopted

- Saturn 6 percent granules: 23 kg/ha.

It should be noted that the growing of recently released Batalagoda cultivars, which are dwarfs and semidwarfs, becomes possible only if weed control is effective.

Pest Control

Pests and diseases are much less troublesome in System B than in the Wet Zone.

Brown plant hopper is an ubiquitous pest that is expensive to control: water must be drained from the field, and Furadan (Carbofuran 3 percent granules) broadcast at the rate of 8 to 9 kg/ha. This application also controls gall midge and yellow stemborer.

Paddy bug attacks the grain in the milk stage, and can be cheaply controlled by the use of BHC 10 percent dust, 22 kg/ha.

The farmer can escape recurrent expenditure on pesticides by using resistant varieties. The cultivars BG 400-1 (4-1/2 months) and BG 276-5 (3 months), both of which were released from Batalogoda in 1979, manifest resistance to gall midge. Breeding at Batalogoda for resistance to brown plant hopper is in its final stages.

Disease Control

The Batalagoda cultivars, H-4 and BG 11-11 are highly resistant to blast, the only troublesome disease in System B. Other cultivars that exhibit some degree of resistance which are suitable for growing in System B include BG 90-2, BG 400-1, BG 94-1, BG 94-2 and BG 276-5. BG 34-8 is classed as moderately resistant to blast.

Paddy Yields

Yields, when not constrained by water stress, become a function of the rice variety and the input package, particularly fertilizer. The complete acceptance by farmers in the Polonnaruwa District of the recently improved cultivars is encouraging. With cultivars BG 11-11 and BG 34-8, Maha paddy yields on major and minor schemes in the Polonnaruwa District have ranged between 3.4 and 7.1 tonnes/ha (see Table E-3.7).

The yield potentials of the cultivars recommended for growing in System B are as follows.

Cultivar	Growth Duration (months)	Year of Release	Yield Potential* (tonnes/ha of paddy)
BG 34-8	3	1971	7.2
BG 34-6	3-1/2	1971	7.2
BG 94-1	3-1/2	1975	7.1
BG 11-11	4-1/2	1970	7.2
BG 90-2	4	1975	8.9
H-4	4-1/2	1958	5.7

The crop-cutting experiments reported in Section 3.2.3 provide further evidence that high paddy yields can be achieved under the project. As discussed in that section, conditions in the Pimburettewa Tank Scheme approximate what is envisaged under the project. In particular, the Maha results are indicative of yield potential when sufficient water is available. The mean Pimburettewa paddy yields in Maha 1979/1980 on the two lowland paddy land classes are shown on the following page.

*As estimated by the Director, Central Rice Breeding Station, based on performance of seed producers.

	Land Class 1R	Land Class 2R
Yield (tonnes/ha)	5.43	5.02

These estimates are indicative of the higher end of the range for realistic "target" yields (i.e. yields attainable by efficient farmers) under the project.

For purposes of calculating project economic and financial benefits, a more conservative estimate has been adopted for the "Base Case" analysis as follows.

	Tonnes/hectare Maha	Tonnes/hectare Yala
Land Class 1R	4.6	4.6
Land Class 2R	4.1	4.1

The rationale for the adoption of these "Base Case" yields for purposes of economic and financial analysis is primarily the following

- yields projected for the 1R soils are below those indicated in the Maha 1979/1980 survey in the Pimburettewa Tank Scheme, reflecting the conservative approach to project economic and financial analysis

- based on the survey results, the yield potential of the 2R soils is set at 90 percent of that of the 1R soil

- although the Yala season is the theoretically preferred growing season (in the absence of water stress), there will still be some limited water stress in the Yala season under the project and thus Yala yields are set equal to Maha yields.

Higher and lower estimates (± 10 percent) are proposed for purposes of sensitivity analysis.

5.2 - Uplands

The net area available for irrigated upland cropping of 1,500 ha is only 4 percent of the net irrigable extent under the project. The choice of crops, however, is wide. Consideration is given in this section to the range of possible crops, while the selection of an upland crop rotation for use in the economic analysis is further discussed in Annex G.

A number of agronomic studies have already investigated what crops could be grown in the uplands of the System B project area. Some preliminary recommendations from these studies are summarized in Table E-5.2. In addition, some indication of probable yields has also been provided, as indicated in Table E-5.3.

In what follows, the agronomic suitability of various crops for the uplands is investigated in some detail.

5.2.1 - Potential Crops that Require Irrigation

Severe percolation losses under flooded irrigation--in excess of 10 mm/day--characterize the well-drained Reddish Brown Earths, the group to which upland cropping will be largely confined. Flooded paddy cultivation is not, therefore, recommended for these soils.

(a) Sugarcane

Sugarcane has been grown in Sri Lanka since 1961 but progress in the industry has been disappointing. Factories have operated at 60 percent or less of their capacities. The quality (percent sugar recovery from cane) was extremely low until 1974. In 1979 the stated objective was to have the

TABLE E-5.2

SOILS AND CROPPING POTENTIAL OF SYSTEM B

Map Unit*	Soil Series	Suggested Crops
1	Ulhitiya	Chillies, onions, goundnuts, soybeans, cowpea, green gram, cotton, sugarcane, tobacco, maize, sorghum, upland paddy, fruit crops, etc
2	Moogamana Ela	Paddy
3	Wilayaya - Ulhitiya - Alawakumbura Series	
	- Wilayaya - Ulhitiya - Alawakumbura	Same crops as Map Unit 1 Already described under 1 Upland paddy
4	Maduru Oya Series	Same as 1 + kenaf, citrus
5	Kathiravali Series	Coconuts
6	Malwattekulam Series	Forestry
7	Total of 3 subgroups	Upland and lowland paddy
8	- Ulpothawewa Series)asso- - Kuda Oya Series)ciation	Upland paddy, groundnuts, lowland paddy, sugarcane, pastures
9	- Ulpothawewa) association - Vakaneri)	Same as Map Unit No. 8
11	Hembarawa Series	Lowland paddy, pastures
12	Handapanwila Series	Lowland paddy, pastures
14,15, 16	Noncultivable	

Source: Land Use Division/Irrigation Department, Soils and Cropping Potentials of Systems A, B, C, and D of Mahaweli project, Colombo, July 1978

*Areas and map units are derived from the 1969 map produced as part of the FAO studies, and reinterpreted by LUD.

TABLE E-5.3

SOILS AND PROJECTED YIELDS FOR
SELECTED UPLAND CROPS IN SYSTEM B
(tonnes/ha)

Crops/ Soil Class	Season	RBE		NCB	Alluvial	
		WD	ID	MD	WD	ID
Sugarcane		75-100	60-85	50-75	85-100	85-100
Cotton (as seed cotton)	Y	1.6-2.2	0.9-1.3	0.9-1.3	1.6-2.2	NR
Maize, Sorghum	M	1.1-1.6	NR	0.9-1.3	1.1-1.6	NR
Maize, Sorghum	Y	1.1-1.6	1.1-1.6	0.9-1.3	1.1-1.6	1.1-1.6
Manioc (= Cassava)	M	25-37	NR	0.9-1.3	NR	25-37
Green gram and Cowpea (seeds)	M	0.8-1.4	NR	0.7-1.1	0.9-1.4	NR
	Y	0.8-1.4	0.8-1.4	0.7-1.1	0.9-1.4	0.9-1.4
Groundnuts (in shells)	M	1.1-1.7	NR	0.9-1.3	1.3-1.9	NR
Groundnuts	Y	1.1-1.7	1.1-1.7	0.9-1.3	1.3-1.9	NR
Soybean (grain)	M	0.9-1.4	NR	NR	0.9-1.4	NR
Soybean (grain)	Y	0.9-1.4	0.9-1.4	0.9-1.4	0.9-1.4	0.9-1.4
Bombay onion	Y	10-13	NR	8-11	11-14	11-14
Red onion	Y	10-13	NR	8-11	11-14	11-14
Chillies (dried)	Y	0.9-1.4	NR	0.8-1.2	1.1-1.6	1.1-1.6
Tobacco (grn)	Y	7.8-8.9	NR	6.7-7.8	8.9-10	8.9-10
Vegetables* I	M	11-12	NR	NR	11-12	NR
	Y	11-12	11-12	NR	11-12	NR
Vegetables** II	M	12-15	NR	NR	12-15	NR
	Y	12-15	12-15	NR	12-15	NR

Symbols: RBE = Reddish Brown Earth soils
NCB = Noncalcic Brown soils
NR = Not recommended
WD = Well drained
ID = Imperfectly drained
MD = Moderately well draine

Source: Reference 3 (NEDECO, 1978)

* Tomatoes, eggplant, capsicum.
**Carrots, beets, cabbage, etc.

Kantalai factory operating at full capacity with 2,740 acres of plant cane and 5,480 acres of ratoons, with a recovery rate of at least 10 percent.

A loan has also been secured to rehabilitate the Hingurana factory and grants have been obtained to take over some 25 000 acres of paddy land surrounding the factory. Future areas planned include 3,750 acres (1,520 ha) of plant cane and 7,500 acres (3,080 ha) of ratoons. At an average yield of 26 tonnes of cane per acre (64.2 TC/ha) and recovery rate of 9 percent sugar on cane, future sugar production is estimated at 26 300 tonnes. Another project envisaged is at Savanagala on the left bank of the Uda Walawe project in southern Sri Lanka. Recently an FAO/IBRD rainfed sugar identification mission also investigated the feasibility of a 2,500-TCD sugar factory in the Monaragala District. As a first stage, 4,500 acres of cane was proposed, to be supplemented later by 9,000 acres of farmer's cane. The total cost would be U.S. $89 million, of which IDA would furnish U.S. $20 million.

The total projected future production of sugar outside the Mahaweli scheme* is as follows (in thousand tonnes).

Location	1985	1990	1995	2000
Kantalai	39.6	51.8	59.0	60.1
Hingurana	26.3	26.3	26.3	26.3
Savanagala	16.9	24.6	26.8	26.8
Monaragala	-	40.6	40.6	40.6
TOTALS	82.8	143.3	152.7	153.8

*Sugar production on a large scale is under consideration for System C. The feasibility studies being conducted at the time of writing by Hunting Technical Services Ltd. contain considerable detail regarding potential production in System C.

A recent ODM-sponsored investigation by ULG Consultants has further recommended growing sugarcane in the Intermediate Zone to the west of Maha Oya, Medagama, Siyambalanduwa, Moneragala, Buttala and Wellawaya. In this case, it is proposed that moisture stress from June to September can be alleviated by relatively low cost supplementary irrigation.

At the same time, cane yields on existing plantations have been relatively low. The Hingurana Estate is typical.

Soil	Age	Yield (tonnes cane/ha)
NCB	First post-forest crop	100
	Replanted crop	70
	Ratoons	35
RBE	Plant cane	75
	First ratoon	63
RAL	Plant cane	88
OAL	Plant cane	very poor

Good husbandry practices are required to maintain soil fertility. The existing irrigation policy which recommends a gross diversion of 1,500 mm (with 1,700 mm of rainfall) also contributes to the low cane yields obtained. Cane yields for the plant crop and three or more ratoons in good sugar-producing countries generally exceed 130 tonnes/ha.

In addition, since the low temperatures required for ripening are not evident in System B, climatic conditions in the region appear to be less suitable for sugarcane than in many other available areas in Sri Lanka.

In System B, however, the real constraint to the introduction of sugarcane is the absence of contiguous and extensive areas of Reddish Brown Earths. The extreme fragmentation of this soil group makes remote the likelihood of securing the large extents required for effective crop management. Admittedly, with the recent trend toward "mini" sugar factories, the need for large, contiguous areas has diminished. However, even a small 400-TCD factory would need a compact sugarcane area of 800 ha. Soil surveys and land classification work (see Annex B) have indicated that there are no such areas in the project area.

In any event, further sugarcane research can be conducted on the proposed Experimental Demonstration Farm. Sugarcane trials should be planted and supervised by a professional who would apply the principles of crop control (involving the monitoring of moisture levels, mineral nutrient levels, and sugar content) and dry the crop using an optimum drying cycle. This information would produce more ample evidence for or against growing sugarcane in the project area (particularly on the poorer soils) and could include an economic comparison of its profitability as compared to other crops.

(b) Cotton

Cotton production in Sri Lanka is desirable to reduce large import requirements. A medium staple suitable for local spinning, e.g., ACALA 1517 D, is preferred. Furthermore, the prospects for cotton in the Dry Zone are bright because the crop flourishes in a climate where the rains are minimal at the time of flowering and boll formation.

Cotton should be grown on well-drained Reddish Brown Earths and also tried on the best of the Noncalcic Brown soils

(Welikanda Series). Cotton must be grown during the Yala season with supplementary irrigation; the heavy rains during the Maha rule out the possibility of successful Maha cotton. Cotton should be planted during February-March and harvested in July-August.

The successful production and marketing of cotton, however, requires very good management for the following reasons.

- Cotton has many insect pests which require careful monitoring in the field by 'scouts' who advise farmers when to spray; sprays may number from 5 to 10 per crop, depending on the incidence of insects. The crop discipline for spraying cotton in many major cotton producting countries is provided by the buying organization with spray planes. For satisfactory control, an entomologist's supervision is advised. For small farmers, intensive extension work is required to ensure that timely spraying takes place. One extension worker per 100 cotton farmers and one knapsack sprayer per farmer is required.

- Cotton seed loses its viability quickly due to heat and moisture. Seed must be kept cool and dry to preserve germination for the following season. It should also be acid delinted and treated with fungicide. This service should be provided by the ginners. Since small farmers are loath to pay for seed, this could be returned to them as a discount against their previous crop.

- The rotation of cotton with other crops is essential--cotton should not be grown more than once in 4 yr. It will benefit by following a green manure crop which is ploughed in, or a leguminous crop, although a long dry season after cotton with no crops may suffice. Rotation is necessary to control pests and diseases. One suggested pattern is:

cotton, soybeans, subsistence crops, soybeans. The green manure crop could be grown in the Yala season and ploughed under in November. All cotton trash and stalks must also be burned.

- Cotton needs very careful irrigation. It must not be overwatered, nor must it suffer stress from drought until it is being dried off for harvest.

- Cotton requires heavy application of NPK fertilizer. Specific rates must be determined on the Experimental Demonstration Farm, but they could well be in the region of 125 kg urea, 125 kg superphosphate and 125 kg potash/ha.

- Considerable marketing infrastructure is also required--storage at the buying station and ginnery, large bags for transport, and a new oil seed mill to extract oil and meal are among the most important items.

Cotton growing in Sri Lanka during the last half-century has suffered from acute mismanagement. Average yields of seed cotton have generally been relatively low at 450 kg/ha to 900 kg/ha. Even these estimates are not reliable, however, since they are based on farmers' subjective estimates[5] of the quantities of cotton they produce and of the acreages they cultivate.

The average seed cotton yield for countries like Sudan and South Yemen is 1,200 kg/ha and 1,340 kg/ha. Accordingly, the average yield on small farms in the project area will probably not exceed 1,200 kg/ha of seed cotton on the RBE soils (1U) and not more than 1,000 kg/ha on the best NCB soil (2U).* Cotton is not recommended on shallow poorly-drained

*Under optimum management conditions, possibly in conjunction with a larger commercial scale landholding pattern, the yields of 1.7 (1U) and 1.4 (2U) tonnes/ha shown in Table E-6.5 should be attainable.

NCB soils, as it has a tap root and requires deep well-drained land.

For System B, cotton research on the Experimental Demonstration Farm is required before farm production is encouraged. This research should include

- developing production procedures for the RBE soils
- determining yields of different varieties via crop cutting experiments
- determining water requirements and fertilizer optima.

(c) Tobacco

Tobacco production is almost entirely governed by the Ceylon Tobacco Company which determines the price paid, provides credit, supplies agrochemicals and fertilizers, and arranges for bank loans for tobacco barn construction. Research on tobacco agronomy is also carried out by the Company. Local production fulfills local requirements. Flue-cured tobacco could be exported and the prospects of growing tobacco in System B on certain soils are good if an export market for flue-cured tobacco can be developed.

Nevertheless, the production and marketing technology required is rather demanding, particularly for small farmers:

- Tobacco is a crop which requires detailed attention and desuckering during its growing period. It also suffers from many fungal diseases, although those can generally be prevented by not smoking tobacco in nurseries or fields, and washing with soap before commencing work on tobacco.

- Tobacco should not be grown more often than once in 2 or 3 yr and stalks should be burnt after harvest. The rotation should include soybeans and subsistence pulses, e.g. tobacco, soybeans, and subsistence crops. If ploughed at the end of the January-February, only supplementary irrigation is required. However, it would be difficult to include both Maha and Yala tobacco crops in a rotation on a small farm.

- Good drainage is essential for tobacco and planting on ridges is advisable.

- Intensive advisory services are necessary to teach farmers good tobacco management. The Ceylon Tobacco Company could assist farmers with advice and credit for growing and curing. The Company has already indicated its willingness to assist with advice on growing and curing the crop if the quality is satisfactory when grown for about 4 yr on the Experimental Department Farm.

- The ownership of barns is beyond the scope of small farmers so the curing operation should generally be carried out by farmer cooperatives which would cure and grade the Virginia leaf for the farmers and then sell it to the Ceylon Tobacco Company.

Tobacco is already produced in the System B area, and yields can be expected to be close to the 1977 national average of 830 kg/ha for flue-cured tobacco.

An initial yield of some 800 kg/ha can be anticipated in System B, but additional research is still required. Test plots on the Experimental Demonstration Farm are essential firstly to determine the quality of tobacco which can actually be grown on the Welikanda series of the Noncalcic

Brown soils, as well as on the Reddish Brown Earths. Specific fertilizer requirements for these soils must also be examined.

5.2.2 - Crops Suitable for Rainfed (Maha) or Irrigated (Yala) Cultivation

The precipitation pattern in System B offers promise of successful rainfed cropping in Maha, which may be profitably exploited on uplands, both within and above irrigation command. The possible crops include groundnuts, soybeans, kenaf, sunnhemp, cassava, sesame, and numerous perennials (coconuts, pineapple, cashew, citrus (limes), and bananas).

(a) Groundnuts

The high food value of groundnuts and their contribution to soil fertility maintenance warrants their inclusion in rotations in System B. Groundnuts require good drainage and therefore can only be contemplated on the better drained Welikanda series of NCB and the well drained Reddish Brown Earth soils. Groundnut seed should be treated with rhizobium to achieve best results but if this is not available it is usual to compensate by applying nitrogenous fertilizer. To achieve good yields it is also necessary to fertilize heavily because, although groundnuts are a legume, they remove substantial quantities of nutrients from the soil. Groundnuts would be harvested in the Yala season to ensure that they dry out quickly and do not become infected with Asperigillus Flavus fungus which causes the formation of aflatoxin, which is harmful to both animals and man.

It is usual to rotate groundnuts with a grain crop or cotton and some irrigation may be needed to prevent stress at pegging when the flower sends the seed shoot down into the soil. At this time the soil should be moist. Supplementary irrigation may also be necessary in RBE soils prior to harvesting to ensure that the groundnuts are not left in the ground. Maha crops, or Yala crops on sandy loam paddy land can be expected to yield from 1,500 to 2,000 kg/ha nuts in shell.

Groundnuts in Sri Lanka are grown exclusively for confectionery purposes in the domestic market. Marketing is therefore spasmodic. The Sri Lanka Cashew Corporation could export groundnuts since overseas customers who purchase cashew nuts also deal in confectionery groundnuts. The nuts for export should be certified free of aflatoxin.

Finally, new varieties of confectionery nuts should be tried out on the Experimental-Demonstration Farm. Suggestions are Mount Makulu Red, Townsend and Mani Pintar. The latter is higher in oil than the normal bunch varieties. Hand operated decorticating machines break fewer nuts than do tractors used as simple threshing machines, and are therefore recommended.

(b) Soybeans

Soybeans are also a desirable crop in System B because of their higher protein content (40 percent) and their contribution to soil fertility maintenance.

The Maha crop should be planted in October and harvested in February, while the Yala crop should be planted in March and harvested in July. Soybeans are an excellent rotation crop and fit into a rotation with either tobacco or cotton. They will probably produce higher yields on the Reddish Brown Earth soils than on the Noncalcic Brown soils. The soils used should always be well-drained and have a low nitrogen fertilizer requirement. Some suggested rotations are

- cotton, soybeans, subsistence crops, soybeans
- cotton, soybeans, subsistence crops, sunnhemp
- tobacco, soybeans, subsistence crops, soybeans
- tobacco, sunnhemp, subsistence crops, soybeans.

Soybeans need good drainage, and are best grown on ridges.

Soybean seed is affected by heat and moisture. It would be wise to perform germination tests on seed a month before planting to enable new seed to be obtained if necessary. This service should be available through the extension service. Seed should be dried to below 13 percent to prevent weevil infectation and to preserve vitality. Rhizobium innoculation of the seed is also necessary for 4 yr, until the soil on the farm becomes heavily inoculated with the Rhizobia.

The fertilizer requirement for soybeans is about 125 kg/ha of triple super phosphate (TSP) and 62 kg/ha urea, which is needed to start the plant off before the nodules form. About 46 kg/ha of muriate of potash (M/P) is also needed.

National yields at present are relatively low at 1,270 kg/ha but with a build up of Rhizobia in the soil, improved cultivation, and a more aggressive marketing organization, yields should rise to an average of 1,600 to 2,000 kg/ha on the RBE soils (1U) and 1,300 to 1,600 on Welikanda Series of the NCB's (2U).

At the same time, the marketing arrangements for the crop must be faultless. The two existing oil mills, Oils & Fats Corporation and British Ceylon Corporation, Colombo, cannot efficiency cope with the extraction of soybean oil which should be done by the solvent process to destroy the Trypsin inhibitor which interferes with the digestive processes in monogastric animals, including man. Solvent extraction also removes the 'beany' flavor which is due to lyposidase enzymes. A new solvent extraction plant should be built in Colombo. This mill would also be able to extract cotton seed oil and paddy bran oil.

Finally, the Experimental-Demonstration Farm should demonstrate the use of Rhizobium and fertilizer on soybeans and carry out trials on the two soil types (RBE and NCB).

Accompanying extension work to encourage soya production will also be necessary.

(c) Kenaf

The agronomy of this fiber crop has received considerable attention at Maha Illupallama and work has begun on its commercial cultivation under rainfed conditions at the Sri Lanka Cashew Corportation Farm, north of Welikanda, and at the National Paper Corporation Farm at Punanai.

Kenaf, when used for pulp, is harvested when dry. The top of the plant is detached to enable the seed to be threshed separately.

Kenaf depletes soil fertility and, therefore, cannot be grown continuously or frequently, particularly on Noncalcic Brown soils on small farms.

Fertilizer requirements per hectare are

- urea	100 kg
- triple super phosphate	125 kg
- muriate of potash	32 kg.

Kenaf needs abundant moisture, but it will not grcw well in poorly drained or shallow soils. Yields of kenaf as a Maha crop on these soils are typically low--about 2.5 to 4.5 tonnes/ha of dried stalks. This crop can only be considered for rotational cropping on Reddish Brown Earth soils. Under optimum cropping conditions yields of 9 tonnes/ha of dried stalks should be possible. The National Paper Corporation paper mill at Valaichchenai is working at full capacity at present but the needs of a new mill could be satisfied with more paddy straw, kenaf as a rotation crop and eucalyptus grown for pulp in wind breaks.

Alternatively, a new mill could be built to process kenaf fiber into gunny bags. However, because kenaf requires as much labor as paddy to produce retted fibers, problems with the family labor supply may arise. Furthermore, fiber extraction by the decortication process may present problems.

The Experimental-Demonstration Farm could encorporate kenaf in a long rotation including sunnhemp but family farms will not likely tolerate long rotations, particularly on marginal soils. A four crop rotation with soybeans, subsistence crops and sunnhemp is one alternative to cotton on the upland RBE's.

(d) Sunnhemp

Like kenaf, the agronomy of sunnhemp has also received attention at Maha Illuppallama. Experience with its commercial cultivation already exists in the project area, at the National Paper Corporation's "Illuk" farm near Punanai. It can be grown in rotation with kenaf, cotton, tobacco and all grains and pulses.

Sunnhemp needs good drainage but can be grown in Yala and ploughed in as green manure in sandy paddy fields just prior to puddling. Sunnhemp as a fiber crop for paper manufacture is planted from December to February and reaped during the dry season. Sunnhemp stalks should yield 1.25 to 2.5 tonnes/ha, dry weight.

The recommended fertilizer application per hectare is

- triple super phosphate - 110 kg
- muriate of potash - 60 kg.

The extension service should encourage sunnhemp production as a green manure crop for all soils. This can also be demonstrated on the Experimental Demonstration Farm. The inclusion of sunnhemp as a fiber crop in a rotation will not deplete the soil unduly.

(e) Cassava

The farmer in Sri Lanka understands cassava. Apart from its local value as human food and livestock feed, the export potential of cassava pellets to developed countries is considerable: the present market for cassava pellets in the EEC area approximates 5 million tonnes/yr, and is expected to show a 50 percent expansion during the next decade. Further discussion of the marketing aspects of the crop can be found in Annex G.

Cassava is grown on sandy soils with low fer[illegible]ity, in soils which have been worn out by over-cropping with cereals or in soils which have become infested with nematodes. Thus, cassava may well be one of the crops which should be grown on the Noncalcic Brown soils, provided that they are well drained. Where the soils tend to become water-logged in the Maha season, cassava should be grown on ridges which will concentrate the shallow top soil.

Groundnuts make an attractive intercrop with cassava, and should, through symbiotic nitrogen fixation, contribute to soil fertility. Yields of 15 to 20 tonnes/ha from a 9- to 12-month* cassava crop are predictable on RBE's in System B.

The shallowness of the soils in question is a limiting factor. It should be a suitable crop to rotate with tobacco, soybeans and green manure. Cassava must be processed directly after lifting--for the cattle feed trade, this involves chipping and sun drying. The roots are washed and chipped with the skins on. To concentrate the chips for transport, they must be pressed into large pellets. This requires a pelleting machine at the port of export.

Extension work on cassava should include the introduction of the highest yielding varieties from trials conducted elsewhere in Sri Lanka.

The Experimental Demonstration Farm should conduct rotation trials to establish cassava as a possible crop for the NCB soils.

(f) <u>Sesame</u>

Sesame or gingelly is one of the few crops possible on unirrigable unlands after Maha in System B. It should be sown in early January as a Meda** crop.

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* Some short-duration varieties can be harvested in 6 to 7 months.

**Meda - the term applied to the cropping season which begins late in the Maha and extends into the Yala.

(g) Perennials

Several promising perennials can be identified. The prospects for extensive coconut growing are bright in System B, particularly in the eastern half. Coconuts are also an attractive crop for the Maduru and Galwewa series of the Noncalcic Brown soils. If pastures are established under coconuts, supplementary Yala irrigation would be desirable. Pineapples are an attractive intercrop in the early years of establishing coconuts. All soils suitable for coconuts can also carry cashews.

5.3 - Cropping Patterns (see Figure E-5)

5.3.1 - Lowlands

Paddy is recommended both as a Maha and a Yala crop for all soils which are suitable for lowland paddy cultivation (1R and 2R land classes). It is expected to be the preferred crop of all lowland farmers.

Double cropping with paddy will include a 135-d cultivar (preferably BG 11-11 or BG 90-2) in Maha, and a 105-d cultivar (preferably BG 34-8) in Yala. For transplanting on about the first of October, nurseries must be sown 3 week earlier. This cropping pattern is presently followed in most lowlands in the project area.

5.3.2 - Floodplains

Transplanting in the floodplains should be delayed until the risk of flooding has declined to a low level, by about January 15. This pattern differs from the lowland pattern only in that a 105-day cultivar is planted in Meda rather than in Maha. The preference is BG 34-8 in both seasons.

5.3.3 - Uplands

A wide diversity of possible cropping patterns exist. Some of the patterns recommended for well-drained RBE's are listed below.

Maha	Yala
Kenaf (140 d)	Tobacco (140 d)
Soybeans (105 d)	Chillies (160 d and
	Onions (90 d)
Groundnuts (110 d)	Soybeans (105 d)
Vegetables (90 to 120 d)	Cowpea (75 d)
Groundnuts (110 d)	Cotton (150 d)
Maize (120 d) with intercrop of upland paddy (90 d)	Pulses (60 to 75 d)

All of these possible patterns including various rotation alternatives should be tested on the Experimental Demonstration Farm. Due to the uncertainty surrounding the potential for some of the crops requiring sophisticated management and/or unusual marketing arrangements, the groundnuts-soybeans pattern is suggested as an indicative pattern to give a conservative estimate of potential economic returns. Due to its longer duration, the groundnut-cotton pattern is used in Section 5.4 to calculate water requirements.

5.4 - Water Requirements for Paddy and Upland Crops

5.4.1 - Evapotranspiration

Diyasenapura, the location from which meteorological data for the calculation of reference crop evapotranspiration (ET_0) were drawn, is only 32 km (20 mi) from Welikanda. ET_0 values derived from the original Penman equation and values calculated from the modified equation[10] developed in FAO Irrigation and Drainage Paper 24[7] are tabulated below

ET_0--Diyasenapura

	J	F	M	A	M	J	J	A	S	O	N	D
Original Penman Eq.	127	126	155	162	189	198	198	205	201	161	126	109
Modified Penman Eq.	132	131	163	181	210	233	229	247	234	172	135	110

The ET_0 values derived from the original Penman equation were used by the investigators who established the station, and were adopted for this study for the calculation of crop water requirements. Only one full year's data (1978/79) are available for Diyasenapura*--a limitation that must be noted in the interpretation of the derived evapotranspiration estimates. Multiplication of ET_0 values by appropriate crop coefficients yield estimates of the consumptive use of water (ET crop). As discussed in Section 5.3, the paddy pattern has been assumed for all 1R and 2R soils (see Figure E-5). The groundnut-cotton pattern has been assumed here for the uplands to give conservatively high crop water requirements.

*The Interim Report[6] describes the problems associated with the estimation of ET_0 from data at longer-term stations. In any case, the ET_0 values calculated for various stations are generally within 10 percent of one another.

5.4.2 - Crop Water Requirements

Values of crop water requirements for three of the cropping patterns envisaged for System B are given in Table E-5.4. The water needs for land preparation for a 15-d period have been estimated by Joshua (1977),[8] at approximately 180 mm for paddy, and 75 mm for upland crops. These estimates have been used in the present calculations.

In the instance of lowland paddy, percolation loss has been estimated at 3 mm/day for 1R soils and 6 mm/d for 2R soils (see Annex C) for the duration of the crop plus the land preparation period. For upland (dry-foot) crops, percolation loss is accounted for in the field efficiency rating.

The estimates of water requirements of inundated paddy given in Table E-5.4 relate to broadcasting in both seasons to give conservatively high theoretical water requirements. Extensive transplanting of rice is envisaged in System B "with the Project", when water-stress hazards are eliminated. The settler will prefer transplanting to direct seeding if the benefits that derive from water economy and weed control outweigh the consequences of higher consumption of manual labor. A quantification of the theoretical differences in crop water requirements between transplanting and broadcasting follows.

The sowing-harvest duration is another factor that impinges on crop water requirements. Generally, with inundated paddy, yields rise with extension of the sowing-harvest duration up to a maximum at about 135 days; further increases beyond this duration confer no yield benefits. On the other hand, shortening of the sowing-harvest duration below about 105 days seriously depresses yields. The yield benefits that accompany the use of longer-duration cultivars are accentuated by transplanting.

TABLE E-5.4

CROP WATER REQUIREMENTS
(mm)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
ET_o - Diyasenapura	127	126	155	162	189	198	198	205	201	161	126	109	1957
Cropping Pattern (A) for Lowlands: Paddy (135d)/Paddy (105d)													
ET paddy - Maha	149	109	23							81	135	127	
- Yala				84	211	228	165	31					
Land preparation			60	120					60	120			
Percolation loss- 1R	90	75	30	75	90	90	75	15	15	75	90	90	
- 2R	180	150	60	150	180	180	150	30	30	150	180	180	
Field water requirements - 1R	239	184	113	279	301	318	240	46	75	276	225	217	
- 2R	329	259	143	354	391	408	315	61	90	351	315	307	
Cropping Pattern (A') for Floodplains: Paddy (105d-20d in nursery)/Paddy (105d-20d) in nursery)													
ET paddy - Meda		72	182	162	66								
- Yala						89	217	222	94				
Land preparation	60	120			40	120	20						
Percolation loss- 1R	15	75	90	85	25	65	90	90	45				
- 2R	30	150	180	170	50	130	180	180	90				
Field water requirements - 1R	75	267	272	247	131	274	327	312	139				
- 2R	90	342	362	332	156	339	417	402	184				
Cropping Pattern (B) for Uplands: Groundnuts (110d)/Cotton (150d)													
ET groundnuts	107	34								35	61	102	
ET cotton			34	116	110	207	182	75					
Land preparation			75							75			
Field water requirement	107	34	109	116	110	207	182	75	-	110	61	102	

Note: Water requirements for the uplands are based on a rotation of groundnuts in Maha and cotton in Yala. This cropping pattern has a higher water consumption than the representative cropping pattern chosen for purposes of economic and financial analysis i.e., groundnuts in Maha and soy beans in Yala.

Table E-5.5 presents the water requirements of inundated rice under four combinations of planting method and sowing-harvest duration. With a cropping pattern of 135-day and 105-day cultivars in Maha and Yala respectively, transplanting in both seasons effects a reduction of 166 mm in the annual consumptive use of water, or about 11 percent.

Predictably, the effects of the sowing-harvest duration on crop water requirements is marked. The substitution of a transplanted 135-day cultivar in Yala for a transplanted 105-day cultivar raises the consumptive use of water by 236 mm, or about 15 percent.

Both the transpiration loss and the transpiration ratio (i.e. the quantity of water transpired per unit yield of dry matter) rise linearly with the increase of the sowing-harvest duration. Moreover, the grain/straw ratio falls with increase in the age of the cultivar. Their higher yield notwithstanding, 135-day cultivars are less efficient in water use than 105-day cultivars. In the case where water is the limiting factor, the theoretically higher potential yields of the later cultivars may not compensate for their greater water consumption. Water consumption is less in Maha than in Yala and the accepted practice is, therefore, to use longer duration varieties in Maha to take advantage of rainfall. Short duration varieties are normally used in Maha to help the farmer control the stagger of planting and harvesting.

The calculations described above serve to demonstrate that significant water savings can be effected by shortening the duration of the Yala crop, both by transplanting and by choosing a short duration variety. This will be particularly important during the early years of the project, when water usage efficiency can be expected to be relatively low and benefits from farm-level water conservation will be correspondingly high and immediate.

TABLE E-5.5

THE EFFECT OF PLANTING METHODS AND OF SOWING-HARVEST DURATIONS ON THE WATER REQUIREMENTS OF THE PADDY CROP

	J	F	M	A	M	J	J	A	S	O	N	D	
Reference Crop Evapotranspiration (ETo) - Diyasenapura	127	126	155	162	189	198	198	205	201	161	126	109	Total
Cropping Patterns (Maha/Yala)													
(i) 135-day cultivar transplanted/105-day cultivar transplanted													
Consumptive Use (ET paddy)	131	46	4	99	222	198	69	-	6	93	144	129	1 141
Land Preparation	-		72	126					72	126		-	396
Crop Water Requirements	131	46	76	225	222	198	69	-	78	219	144	129	1 537
(ii) 135-day cultivar transplanted/105-day cultivar broadcast													
Consumptive Use (ET paddy)	131	46	-	84	211	228	165	31	6	93	144	129	1 268
Land Preparation	-		60	120					72	126		-	378
Crop Water Requirements	131	46	60	204	211	228	165	31	78	219	144	129	1 646
(iii) 135-day cultivar broadcast/105-day cultivar broadcast													
Consumptive Use (ET paddy)	149	109	23	84	211	228	165	31	-	81	135	127	1 343
Land Preparation	-		60	120					60	120		-	360
Crop Water Requirements	149	109	83	204	211	228	165	31	60	201	135	127	1 703
(iv) 135-day cultivar transplanted/135-day cultivar transplanted													
Consumptive Use (ET paddy)	131	16	4	94	215	235	205	75	6	93	144	129	1 377
Land Preparation	-		72	126					72	126		-	396
Crop Water Requirements	131	46	76	220	215	235	205	75	78	219	144	129	1 773

5.5 - Homestead Production

A well-planned, productive homestead will be a great asset to settlers in System B. In terms of cropping intensity, it can be the highest possible and in terms of economic productivity at maturity, it can equal that of paddy production. In terms of providing vitamins and minerals to the farm family, it surpasses every other production system. Fortunately, the rural people of Sri Lanka are familiar with this system and know the value and importance of many crops and plants. The only thing that might be new to many will be the cultivation of fodder crops. Furthermore, as an ecological system it is almost as effective as a mixed forest. In addition to its own litter, animal excrement will also augment soil fertility.

Homestead production employs available labor very efficiently. It fills up idle time during lulls in the production of the main crops (paddy and upland) yet easily avoids the peaks in labor demand for these crops. Once a homestead is planted, it requires minor maintenance and harvesting, with relatively minor labor peaks. In general, it is the farm wife who will maintain it and make use of it.

The crops that will be grown on the homestead can be grouped according to purpose, duration, and soil/water requirements. The fertility requirement will be met by farmyard manure and other natural (organic) manures as well as by chemical fertilizers (if necessary). Crops include

- Perennial fruits: mango, jak, citrus, cashew, avocado, rambutan, bread fruit

- "Annual" fruits: banana, pineapple, papaw, passion fruit

- Fodder crops: pennisetum purpureum (elephant grass, clonal selections and hybrids between P. purpureum x P. typhoides need to be tested); Panicum maximum (Guinea grass); Setaria sphacelata; and Sorghum vulgare (sorghum). These are all grasses that can be planted vegetatively or by seed and be cut several times a year. Pennisetum purpureum can give very high yields and responds very well to high nitrogen doses (production potential up to 25 tonnes dry matter/ha). Leguminous fodders are: Leucaena Leucocophala, Sesbania grandiflora, Stylosanthes gracilis, and S. humilis. Another crop that can be grown as a fodder and for human consumption (pods and roots) is Psophocarpus pallutris (winged bean). These legumes may be interplanted with the grasses. All fodders would be cut in a rotation system according to their best stage of feed value and regrowth capacity

- Coconut/Pasture: Coconut can be dwarf, tall or hybrid. On shallow soils it may be better to grow dwarf or hybrid coconut. Grass on 6U* land will be Brachiaria brisantha; on 6R, Brachiaria mutica. Grasses that need to be tested before introduction are: Chloris gayana, Cynodon spp., Melinis minutiflora, and other grasses that can stand treading both for the upland soils and the lowland soils. Combinations of grasses with legumes should also be tried. Stylosanthes humilis is probably the most promising (several varieties) but Calopogonium mucunoides, Centrosema pubescens and Pueraria phaseoloides can also be tried.

*See Annex B "6U" soils are those which would be classed as Upland soils due to their drainage characteristics, but which have soil texture, depth or topographic limitations to their use under irrigation. "6R" soils are soils which would be classed as paddy soils due to their drainage characteristics, but which also have serious texture, depth or topographic limitations.

- Vegetables: These can be vegetables for the farmer's own use or for the market, including chillies, sweet pepper, okra, eggplant, tomato, onion, cabbage, spinach (*Amarathus*), beans, peas, and rootcrops

- Miscellanous: There are many more crops that can and certainly will be grown on the homestead. These crops will generally be represented by a few or even one plant, but they are of great importance to the farm family. They include the medicinal plants, spices and stimulants. Another useful group of plants will be the multipurpose plants like bamboo, drumstick (muranga) and *Glyricidia* (hedge, firewood and fodder).

5.6 - Fisheries and Fishing

Protein foods other than from pulses are often not available for religious reasons. Fish, however, is a generally acceptable food and even if it is not caught by the consumer it can be readily purchased, either fresh, smoked or dried.

The Fisheries Department have stocked most tanks and rivers and have *Tilapia mossambica*, *T. melanopleura*, *T. nilotica*, and *T. hornorwey* available for stocking in new tanks or fish ponds. Other fish of commercial importance in Sri Lanka are: *Etroplus surantensis*, *Labeo dussumieri*, *Wallago attu*, *Pantics dorsalis*, *Ompuk dimacculatus* and the common carp.

It is suggested that, besides stocking the Maduru Oya reservoir, the Fisheries Department could provide the supervision required to grow the above mentioned *Tilapia* species in small fish ponds among the settlements. These fishponds would be constructed in poorly drained sites and issued to "fish farmers" (instead of issuing paddy land). They would be given the normal upland homestead and cropping area for their subsistence crops other than paddy. Similar conditions could be applied to fishermen on the main tank.

Irrigation water would be provided for these fishponds, although care must be taken not to place fishponds directly below paddy fields which might discharge water containing damaging concentrations of agrochemicals. Undrainable places should also be stocked with fish even if they are likely to dry out in Yala. The fish can simply be harvested and ponds restocked the following season.

Tree stumps must be removed from the tank basin area because of the long time required to rot the trees (over 50 yr) and because net fishing is greatly hindered by the presence of high stumps.

Overstocking will result from lack of fishing. Tilapia mossambica is easily caught on hooks but T. melanopleura and T. nilotica are herbivorous-they eat grass and water weeds and are thus best caught in nets.

5.7 - Other Agronomic Considerations

5.7.1 - Land Clearing

Over most soil types in the project area (except some of the paddy land) there is a dense cover of bush and trees. Some of these trees will be of economic importance and should be saved for timber construction. Building poles should also be saved.

Irrespective of how land is cleared, charcoal recovery could partially repay the cost of clearing. (Although charcoal is not in large demand in Sri Lanka, it is in short supply in India.) Charcoal can be produced in portable kilns in brick-lined pits,* or in large trenches.** The value of this charcoal should be recognized, particularly in the light of the long-term fuel deficit which could develop in the region (see Annex H - Forestry).

5.7.2 - Windbreaks

High evaporation rates occur during the Yala season between mid-May and mid-October when hot dry winds blow from the southwest. It is therefore recommended that, where practicable, natural wind breaks, 25-m wide, be left perpendicular to the direction of the prevailing wind at 300-m intervals. Half of these wind breaks could be cut out later and planted to Eucalyptus camaldulensis to replace imported wood pulp for the National Paper Corporation's Valaichchenai mill. After 5 more years when the first eucalyptus trees have matured, the remaining natural windbreak could also be cut and planted with eucalyptus.

* This method is currently being tested by the State Timber Corporation at Yakkure, in the southwestern portion of the project area.

**This method would produce lower quality charcoal, but may be the only practical means of handling the large quantities involved.

5.8 - Final Comments

To develop viable family farms in System B under conditions of maximum population settlement, numerous criteria must be employed to determine the final crop mix. These include the following.

Agronomics

- The crop must suit the soil type. A mix of crops which will produce the most efficient utilization of the various soil types in System B is desirable. Paddy will, therefore, dominate the cropping pattern due to the predominance of lowland type soils.

- The crop must be workable by farmers with limited agricultural expertise. Crops needing advanced expertise in management and processing require specialist extension staff.

- Crops which suffer from a build-up of diseases, soil-borne pests, or insect pests need to be grown in rotations with maximum intervals between planting dates.

- In rotation or on the homesteads, basic self-sufficiency crops should be included in addition to paddy, e.g., chillies, onions, pulses, and vegetables.

- Rotations must allow for labor requirements for transport and farm storage. Extra labor for harvesting paddy is normal. School children (5 to 14 yr) are not available during school time.

- Draft animals must have grazing or fodder areas. Paddy straw can also be used for livestock. Livestock requirements are elaborated upon in Annex F.

- The homestead sites should be chosen with a view to growing perennials and other household crops around the house because they will be perpetual assets.

Marketing and Economics

The following considerations will have an important bearing on the final selection of upland crops.

- The supply of the crop elsewhere in Sri Lanka.

- The contribution of the crop to import substitution and/or the generation of a lucrative export market.

- The existence of or potential for marketing infrastructure for both local and export markets. Reliable product prices and a reliable product and input delivery system must be in place.

- The secondary benefit potential of the crop, through its ability to support agroindustry. Backward and forward "linkages" with the rest of the economy (vertical integration) are highly desirable.

- The crop should have a high net value per unit area. The financial returns should be adequate to encourage additional farm production.

These questions are considered in Annex G on Agroeconomic Studies.

6 - AGRONOMIC REQUIREMENTS TO REALIZE PROJECT BENEFITS

6.1 - Agricultural Inputs

Input requirements with respect to seed, fertilizer, agro-chemicals, farm power, and labor for paddy, groundnuts, soybeans, pulses, cotton, kenaf, tobacco, cassava, and sugarcane are indicated in Tables E-6.1 to E-6.9.

6.2 - Labor and Farm Power Requirements

Labor and farm power requirements throughout the year have been tabulated for double-cropped lowland and floodplain paddy, and upland groundnuts and soybeans. These estimates are provided in Tables E-6.10 through E-6.12.

To determine where labor bottlenecks may arise, it is estimated that there are 2.8 man units* available per farm family. Thus, with 24 working days/month, the total man units available per month are approximately 2.8 x 24 equals 67.2 man units per month. Reference to Table E-6.10 then suggests that for lowland paddy, a labor bottleneck may arise in March unless threshing is mechanized using small engine-powered threshers. In the case of floodplain paddy (Table E-6.11), however, a labor bottleneck may arise in May of each year irrespective of how the threshing is done, due to the

*Based on 1.0 units for the husband, 0.8 for his wife, and 0.5 for each of two children over 8 yr of age.

TABLE E-6.1

PADDY: INPUT REQUIREMENTS PER HECTARE

Season	Maha	Maha	Yala	Yala
Land class	1R	2R	1R	2R
Yield-tonnes/ha of paddy	4.9	4.0	5.1	4.2

Items		Units	
Materials			
Seed		kg	52
Fertilizer:	Urea	kg	215
	TSP	kg	75
	M/P	kg	50
Insecticide:	BHC 10 percent dust	kg	22
	Furadan	kg	8
	Dimethoate 40 percent EC	mL	226
Weedicide:	Saturn 6 percent	kg	23
Labor (Lowland)			
Nursery		man-days	10
Land preparation and repairing channels		man-days	25
Uprooting seedlings and transplanting		man-days	30
Handweeding		man-days	12
Fertilizer applications		man-days	4
Spraying weedicide and insecticide		man-days	4
Irrigation and drainage		man-days	12-15
Harvesting and stacking		man-days	40
Threshing - machine		man-days	2
- buffalo		man-days	18
Processing and interval transport		man-days	15
TOTAL - with machine threshing		man-days	154-157
- with buffalo threshing		man-days	170-173
Farm Power			
Land preparation		buffalo-pair-days	15
Buffalo threshing		buffalo-pair-days	18
Machine threshing		machine-days	2
Transport		buffalo-pair-days	3
TOTAL with buffalo threshing			36

TABLE E-6.2

GROUNDNUTS: INPUT REQUIREMENTS PER HECTARE

Season	Maha	Maha	Yala	Yala
Land class	1U	2U	1U	2U
Yield tonnes/ha of nuts in shell	1.7	1.5	2.0	1.7

Items		Units	
Materials			
Seed		kg	96
Fertilizer:	Urea	kg	90
	TSP	kg	125
	M/P	kg	60
Insecticide:	Dimethoate	ml	678
Weedicide:	Linuron	kg	2.25
Labor			
Land preparation		man-days	10
Row seeding		man-days	10
Weedicide application		man-days	2
Manual/mechanical weeding		man-days	15
Pest control		man-days	4
Fertilizer application		man-days	6
Irrigation and drainage	- Maha	man-days	2
	- Yala	man-days	14
Harvesting		man-days	43
Transport, threshing and processing		man-days	21
TOTAL	- Maha	man-days	113
	- Yala	man-days	125
Farm Power			
Land preparation with 2-wheel tractor			
- ploughing		tractor-hours	20
- harrowing		tractor-hours	10
TOTAL			30

TABLE E-6.3

SOYBEANS: INPUT REQUIREMENTS PER HECTARE

Season	Maha	Maha	Yala	Yala
Land class	1U	2U	1U	2U
Yield tonnes/ha	1.6	1.3	2.0	1.6

Items	Units	
Materials		
Seed	kg	68
Rhizobium innoculum	kg	0.35
Fertilizer: Urea	kg	62
TSP	kg	125
M/P	kg	46
Insecticide: Monocrotophos 60 percent EC	L	0.7
Weedicide: Linuron 50 percent	kg	1.5
Labor		
Land preparation	man-days	10
Row seeding	man-days	10
Weedicide application	man-days	2
Manual/mechanical weeding	man-days	15
Pest control	man-days	4
Fertilizer application	man-days	6
Irrigation and drainage - Maha	man-days	2
- Yala	man-days	14
Harvesting	man-days	45
Transport, threshing and winnowing	man-days	23
TOTAL - Maha	man-days	117
- Yala	man-days	129
Farm Power		
Land preparation with 2-wheel tractor		
- ploughing	tractor-hours	20
- harrowing	tractor-hours	10
TOTAL		30

TABLE E-6.4

PULSES: INPUT REQUIREMENTS PER HECTARE

Season	Maha	Maha	Yala	Yala
Land class	1U	2U	1U	2U
Yield tonnes/ha	1.7	1.5	2.0	1.7

Items		Units	
Materials			
Seed		kg	23
Fertilizer:	Urea	kg	62
	TSP	kg	125
	M/P	kg	46
Insecticide:	Monocrotophos 60 percent EC	L	1
Weedicide:	Linuron 50 percent	kg	2.25
Labor			
Land preparation		man-days	10
Row seeding		man-days	10
Weedicide application		man-days	2
Manual/mechanical weeding		man-days	15
Pest control		man-days	3
Fertilizer application		man-days	5
Irrigation and drainage	- Maha	man-days	2
	- Yala	man-days	13
Harvesting		man-days	25
Threshing, etc.		man-days	14
TOTAL	- Maha	man-days	86
	- Yala	man-days	97
Farm Power			
Land preparation with 2-wheel tractor			
- ploughing		tractor-hours	10
- harrowing		tractor-hours	10
TOTAL			20

TABLE E-6.5

COTTON: INPUT REQUIREMENTS IN YALA, PER HECTARE

Land class	1U	2U
Yield tonnes/ha of seed cotton	1.7	1.4

Items		Units	
Materials			
Seed		kg	34
Fertilizer:	Urea	kg	125
	TSP	kg	125
	M/P	kg	125
Insecticide:	Carbaryl	kg	10.0
	Monocrotophos	L	5.6
Labor			
Land preparation		man-days	24
Row seeding		man-days	16
Weed control		man-days	20
Pest control		man-days	36
Fertilizer application		man-days	5
Irrigation and drainage		man-days	16
Harvesting		man-days	70
Transport		man-days	20
TOTAL		man-days	197
Farm Power			
Land preparation		2-wheel tractor-hours	30

TABLE E-6.6

KENAF: INPUT REQUIREMENTS PER HECTARE

Season	Maha	Maha
Land class	1U	2U
Yield tonnes/ha of retted fiber	1.9	1.5

Items	Units	
Materials		
Seed	kg	17
Fertilizer: Urea	kg	100
TSP	kg	125
M/P	kg	32
Insecticide: Carbaryl 85 percent SP	kg	1.5
Labor		
Row seeding, weeding, fertilizer application, harvesting, transport and processing of fiber	man-days	170
Farm Power		
Land preparation with 2-wheel tractor		
- ploughing	tractor-hours	10
- harvesting	tractor-hours	10
TOTAL		20

TABLE E-6.7

TOBACCO: INPUT REQUIREMENTS IN YALA, PER HECTARE

Land class	1U	2U
Yield tonnes/ha of cured leaf	1.2	1.0

Items		Units	
Materials			
Seedlings		kg	15 000
Fertilizer:	Urea	kg	112
	TSP/CSP	kg	225
	Sulphate of potash	kg	140
Insecticide:	Thiodan	L	1.1
Fungicide:	Perenox	kg	2
Labor			
Nursery		man-days	40
Land preparation		man-days	65
Transplanting		man-days	17
Weeding		man-days	15
Pest and disease control		man-days	14
Fertilizer application		man-days	12
Irrigation and drainage		man-days	16
Harvesting		man-days	75
Transport, drying, curing, etc		man-days	48
TOTAL			302

TABLE E-6.8

CASSAVA: INPUT REQUIREMENTS IN MAHA, PER HECTARE

Land class	1U	2U
Yield tonnes/ha of fresh roots	20	15

Items	Units	
Materials		
Stem cuttings		5,000
Fertilizer: Urea	kg	75
TSP/CSP	kg	30
M/P	kg	75
Labor		
Planting, weeding, earthing-up, fertilizer application, harvesting and internal transport, cutting and drying	man-days	70
Farm Power		
Land preparation with 2-wheel tractor - ploughing	tractor-hours	14

TABLE E-6.9

SUGARCANE: INPUT REQUIREMENTS PER HECTARE

Land class	Land Class 1U			Land Class 2U		
	Plant	First	Second	Plant	First	Second
Crop	Cane	Ratoon	Ratoon	Cane	Ratoon	Ratoon
Yield tonnes/ha of cane	79	64	57	69	57	52
	Mean Yield=67 t/ha			Mean Yield= 59 t/ha		

(a) Plant Cane (14 months)

Items		Units		
Materials				
Seed cane		tonnes	6	
			1U	2U
Fertilizer:	Urea	kg	185	230
	TSP	kg	94	118
	M/P	kg	100	125
Weedicides:	Paraquat	kg	0.6	
Labor				
Land preparation and planting seed cane		man-days	55	
Weed control and earthing-up		man-days	20	
Fertilizer application		man-days	6	
Irrigation and drainage		man-days	30	
Harvest and transport		man-days	75	
TOTAL			186	
Farm Power				
Land preparation with 4-wheel tractor				
- ploughing		tractor-hours	10	
- harrowing		tractor-hours	5	
- furrowing and ridging		tractor-hours	5	
TOTAL			20	

(b) Ratoon (12 months)

Materials			
Fertilizer:	Urea	kg	230
	TSP	kg	118
	M/P	kg	125
Labor			
Weed control		man-days	15
Fertilizer application		man-days	5
Irrigation and drainage		man-days	30
Harvest and transport		man-days	60
TOTAL			110
Total No. of man-days for plant cane crop and 2 ratoons			406

TABLE E-6.10

LOWLAND PADDY: SEASONAL DISTRIBUTION OF LABOR AND FARM POWER (135 days and 105 days)

Operation	Units*	Month J	F	M	A	M	J	J	A	S	O	N	D	Total MD	BD
Nursery	MD			10						10				20	
Land preparation and	MD			25						25				50	
repairing channels	BD			15						15					30
Uprooting seedlings and transplanting	MD				30						30			60	
Handweeding	MD					12						12		24	
Fertilizer application	MD					4						2	2	8	
Spraying weedicides and insecticides	MD					4						2	2	8	
Irrigation and drainage	MD	2		2	4	4	2			2	4	4	3	27	
Harvesting and stacking	MD		40					40						80	
Threshing (machine)	MD			2					2					4	
(buffalo)	BD			18					18						36
	MD			18					18					36	
Processing and interval transport	MD			15					15					30	
Transport	BD			3					3						6
TOTAL (machine	MD	2	40	54	34	24	2	40	17	37	34	20	7	311	
threshing)	BD			18					3	15					36
(buffalo	MD	2	40	70	34	24	2	40	33	37	34	20	7	343	
threshing)	BD			36					21	15					72

*MD = man/woman day
BD = buffalo/oxen pair day

TABLE E-6.11

FLOODPLAIN PADDY: SEASONAL DISTRIBUTION OF LABOR AND FARM POWER (105 days and 105 days)

Operation	Units*	Month J	F	M	A	M	J	J	A	S	O	N	D	Total MD	BD
Nursery	MD	10				10								20	
Land preparation and	MD	25				25								50	
repairing channels	BD	15				15									30
Uprooting seedlings and transplanting	MD		30				30							60	
Handweeding	MD			12				12						24	
Fertilizer application	MD			4				4						8	
Spraying weedicides and insecticides	MD			4				4						8	
Irrigation and drainage	MD	2	4	4	2	2	4	4	2					24	
Harvesting and stacking	MD					40				40				80	
Threshing (machine)	MD						2				2			4	
(buffalo)	BD						18				18				36
	MD						18				8			36	
Processing and interval transport	MD						15				15			30	
Transport	BD						3				3				6
TOTAL (machine	MD	37	34	24	2	77	51	24	2	40	17			308	
threshing)	BD	15				15	3				3				36
(buffalo	MD	37	34	24	2	77	67	24	2	40	33			340	
threshing)	BD	15				15	21				21				60

*MD = man/woman day
BD = buffalo/oxen pair day.

TABLE E-6.12

UPLAND GROUNDNUTS: (110 DAYS) AND SOYBEANS (105 days):
SEASONAL DISTRIBUTION OF LABOR AND FARM POWER

Operation	Units*	Month												Total	
		J	F	M	A	M	J	J	A	S	O	N	D	MD	TH
Land preparation	MD			10						10				20	
ploughing -															
2-wheel tractor	TH			20						20					40
harrowing -															
2-wheel tractor	TH			10						10					20
Row seeding	MD				10						10			20	
Weedicide	MD				2						2			4	
Manual/mechanical weeding	MD				8	7						15		30	
Pest control	MD					4					1	2	1	8	
Fertilizer application	MD				4	2					4	2		12	
Irrigation and drainage	MD			2	4	4	3	1		1	1			16	
Harvesting	MD	43						23	22					88	
Transport, threshing and processing	MD	5	16					13	10					44	
TOTAL	MD	48	16	12	28	17	3	37	32	11	18	19	1	242	
	TH			30						30					60

*MD = man/woman day
TH = tractor-hours (2-wheel).

compressed cropping calendar. Hired labor should be available from the surrounding farms, however, since May is a low labor requirement month for both lowland and upland farmers. In contrast, Table E-6.12 suggests that 1 ha of upland groundnuts and soybeans can easily be operated by the assumed farm family without hired labor. Based on the most labor intensive month (January), upland settlers should, in fact, be able to farm about

$$67.2/48 = 1.4 \text{ ha}$$

without recourse to hired labor.

In general, most proposed farm units should be able to manage with 2.8 labor units (man-days) available per day in peak periods, with one buffalo/ha on lowlands and adequate mechanical power on the uplands. These labor requirements, on the other hand, can be used to guide settler selection. Families with older children could be favored for the paddy farms, whereas 1-ha upland farms may not have the same restrictions.

6.3 - Farm Implement Requirements

Table E-6.13 summarizes the equipment that is necessary for 1-ha lowland and upland farms. The capital requirement is Rs 430/yr.

6.4 - Farm Input and Product Delivery System

Cropping under full irrigation is "industrialized" farming even though it is small farming. The farmer has to be certain about his input supply and product markets. This can

TABLE E-6.13

ANNUAL INVESTMENT COSTS FOR IMPLEMENTS ON LOWLAND AND UPLAND FARMS, (PER HECTARE)

Implement	No. of Tools per Farm		Depre-ciation (yr)	Price/ Unit (Rs)	Investment Cost/ Farm/Year	
	Lowland	Upland			Lowland	Upland
Plough	1/2	1/2	5	150	15	15
Wooden harrow	1/2		5	40	5	
Iron harrow		1/2	8	160		10
Leveler	1/2		5	35	4	
Hoe	3	3	3	45	45	45
Weeder (paddy)	1		5	105	21	
Shovel (weeder)		1	5	40		16
Tiller		1	5	50		10
4-row seeder (hand pulled paddy)	1/10		5	60	1	
3-row seeder (upland)		1/2	8	1,000		65
Sprayer	1/5	1/5	5	900	36	36
Power sprayer	1/20	1/20	5	4,100	41	41
Sickel	3	3	3	12	12	12
Thresher (paddy)	1/10		5	9,000	180	
Processing equipment		1/10	5	5,000		100
Buckets, baskets, knives, etc	3	3	1	25	75	75
Total Investment/Farm/Year					435	425

Note: For the homestead, no special investment in equipment has to be made.

Maintenance is done by the farmers themselves. The operating cost of engine-powered equipment is not included.

The above costs are allowed for in the economic analysis under the following headings
- Farm power (paddy thresher) in crop budgets
- Settlement allowance for tools (Rs 200)
- Miscellaneous requirements in crop budgets.

be done by the farmer himself as a member of a Multipurpose Cooperative Society (MPCS). It is strongly suggested that this organization be given the full support of Government and that it become a truly farmers' organization. More than any other government-organized structure, the farmers' cooperative should be given the opportunity to develop into an organization that is fully capable of dealing with all of the farmers' interests and concerns.

The detailed structure of Cooperatives will be dealt with in Annex K. Its main function in the supply of inputs and product marketing is outlined below.

Credit*

At the present time, regulations stipulate that a farmer must be a member of the Cooperative to be eligible for credit from the Rural Bank. This means that the Rural Bank functions as a Cooperative bank. It is considered that the Cooperative should advise the Bank on the production credit a farmer needs and carry a certain responsibility for its repayment.

Input Supply

If the MPCS is to successfully provide inputs to farmers, it must have selling points in every hamlet of 125 to 250 farmers. In all of these, there must be a sufficient stock of all inputs that a farmer needs at the beginning of the season. These include fertilizers, chemicals, and common implements (hoes, sickles, weeders, etc). The outlets should also function as suppliers of high quality seed if the farmers order it in time. Members would be permitted to buy on credit, nonmembers would only pay in cash (plus an administration fee).

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*Credit is discussed in greater detail in Annex G.

Up to five "boutiques" would belong to a branch of the primary Cooperative. One branch is normally operated in a village of 500 to 1,000 farmers. The branch has a depot where everything is in sufficient supply to stock the boutiques. The depot is open every day and the boutique is open at least once a week on a fixed day (market day). At the primary level (which more or less coincides with a division) purchases are made to supply the depots and boutiques. The primary MPC has a warehouse for storing a sufficient stock of everything that might be needed by the farmers for the next half year. Sufficient transportation facilities for a regular supply to the boutiques are also maintained.

Primary Cooperative Warehouse
(Purchasing Agent)
↓
Branch - Depot
(500 - 1,000 farmers)
↓
Boutiques
(125 - 250 farmers)

Product Marketing

The MPCS should also function as much as possible in the marketing of the main products of farm members. The branches would function as collection-purchasing points. The Cooperative would be responsible for informing the farmers on quality standards and the prices that are paid for the different grades of each crop for which it is a recognized buyer. Members of the Cooperative would have the proceeds from the sale of their crop deposited in their bank account after subtracting production credit costs (cultivation loans). They should have free access to their credit account at any time. Nonmembers would be paid in cash after subtracting an administration fee.

The Branches should have sufficient storage capacity for products for at least 1 week. They must also have the facilities to improve the quality of the products by drying and cleaning. The Cooperative at the primary level would be responsible for further selling of the products and must be absolutely free to sell to the highest bidder. This can be on a competitive basis to any buyer or on contract to private or government corporations like the Paddy Marketing Board. The basic proposal here is for the Cooperative to serve the interests of the farm members and not the interests of the buyer/consumer. The function of the Government has to be to set a minimum price for every important product to be purchased by its agencies, to function as an incentive to farmers to produce more, or as a discouragement, to produce less. However, stable prices are the best basis for good farming and the Cooperatives have an important function to obtain these in negotiation with the Government or with exporters. This, of course, cannot be done by each primary Cooperative separately. For that purpose, they will have to unite in an Economic Cooperative Federation at the project, district or national level.

7 - AGRICULTURAL RESEARCH

Research at Maha Illuppallama has contributed considerably to the solution of agricultural problems in the agroecological zone DL_1. But the problems of the farmer in System B are different for at least two reasons.

- System B is in the agroecological zone DL_2, which has a distinctly different precipitation pattern.

- This system includes an extensive area under NCB's, a soil group that does not exist in the Maha Illuppallama area.

It is opportune that an "Experimental and Demonstration Farm for Irrigation Agronomy and Water Management" is to be established in the project area by the FAO under UNDP financing. The location has been selected to allow work to begin immediately, since there is a water supply available from the Pimburettewa Main Canal. The 40 ha (100 acres) site includes all four of the NCB soil series.

It is proposed that the Experimental-Demonstration Farm for adaptive research in System B be combined with the Agrarian Development Service Center which would integrate research, training, and extension under one umbrella organization. This is discussed in detail in Annex K.

The activities of this Farm should include, in particular, the execution of the research program which has particular reference to the NCB's and covers:

- Soil-plant-water relations

- The effect of water management practices on
  - crop growth and development
  - weed control
  - fertilizer response
  - nutrient availability
  - soil toxicities.

- The formation of cropping patterns appropriate to the soil categories in System B.

The specific crops which should be considered include: paddy, sugarcane, cotton, tobacco, groundnuts, soybeans, kenaf, sunnhemp, cassava and perennials. The proposed activities for each of these crops on the Farm are indicated in Sections 5.1 and 5.2. Specific proposals for experimental work with the crops discussed in these sections are as follows.

Paddy

- Derivation of economic optimum fertilizer application rates.

- Soil specific fertilizer response and water management considerations.

Sugarcane

- Crop trials which carefully apply the principles of crop control, including the monitoring of moisture levels, mineral nutrient levels and sugar content.

- Experimentation with the potential of the NCB soils versus the RBE's under optimum management conditions.

- Investigation of the behavior of ratoon crops on the NCB's.

Cotton

- Derivation of production procedures for the RBE soils.
- Varietal trials-yield potential, diseases, etc.
- Water management and fertilizer trials.
- Investigation of rotational requirements.

Tobacco

- Quality trials on RBE and Welikanda NCB's.
- Investigation of rotational requirements.
- Fertilizer trials.

Groundnuts

- Trials of new varieties, e.g. Mount Makulu Red, Townsend and Mani Pintar.

Soybeans

- Crop trials on RBE and Welikanda NCB's.
- Demonstration of the use of *Rhizobium* and fertilizer.

Kenaf

- Include in rotational trials.

Sunnhemp

- Include in rotational trials and demonstrations.

Cassava

- Include in rotational trials on the NCB's.

Perennials

- Trials of coconut and irrigated and unirrigated pasture on the less productive NCB series should be conducted.

Because some of the work suggested above will call for use of RBE soils which are not found on the farm site, some "off-site" work will be needed. This can be integrated into the "demonstration" side of the Farm's function, which should emphasize farmer participation.

A small seed testing laboratory is also desirable. Laboratory personnel should do field inspections and roguing, as well as germination and purity tests.

The Farm should also possess facilities for the testing of advance breeding lines and for the production of foundation seed on which a seed certification scheme can be based.

It is encouraging to note that an "Agricultural Extension and Adaptive Research Project" sponsored by the World Bank will commence functioning in Sri Lanka in January 1980. This project will maintain close liaison with the Experimental Demonstration Farm in System B.

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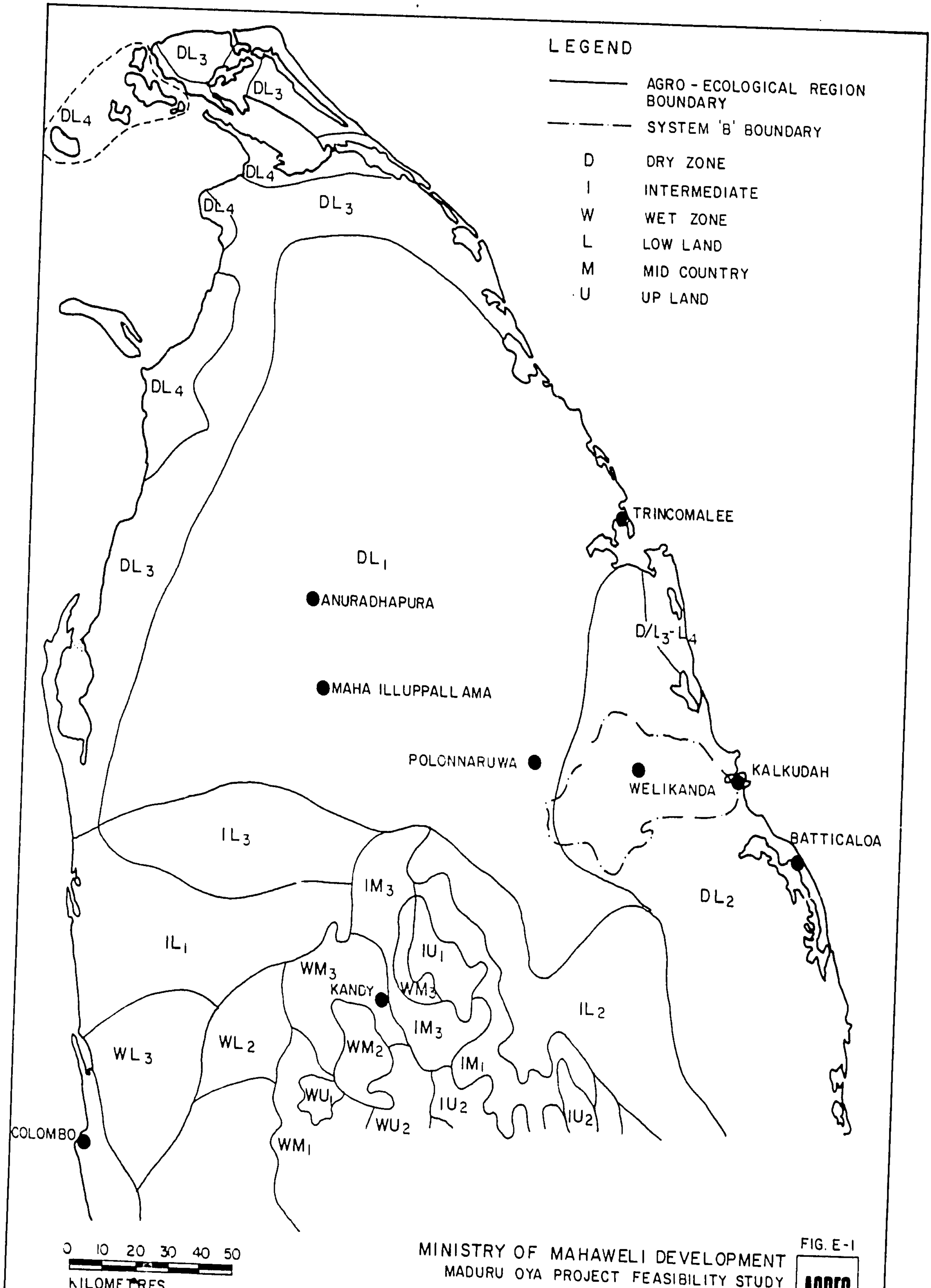
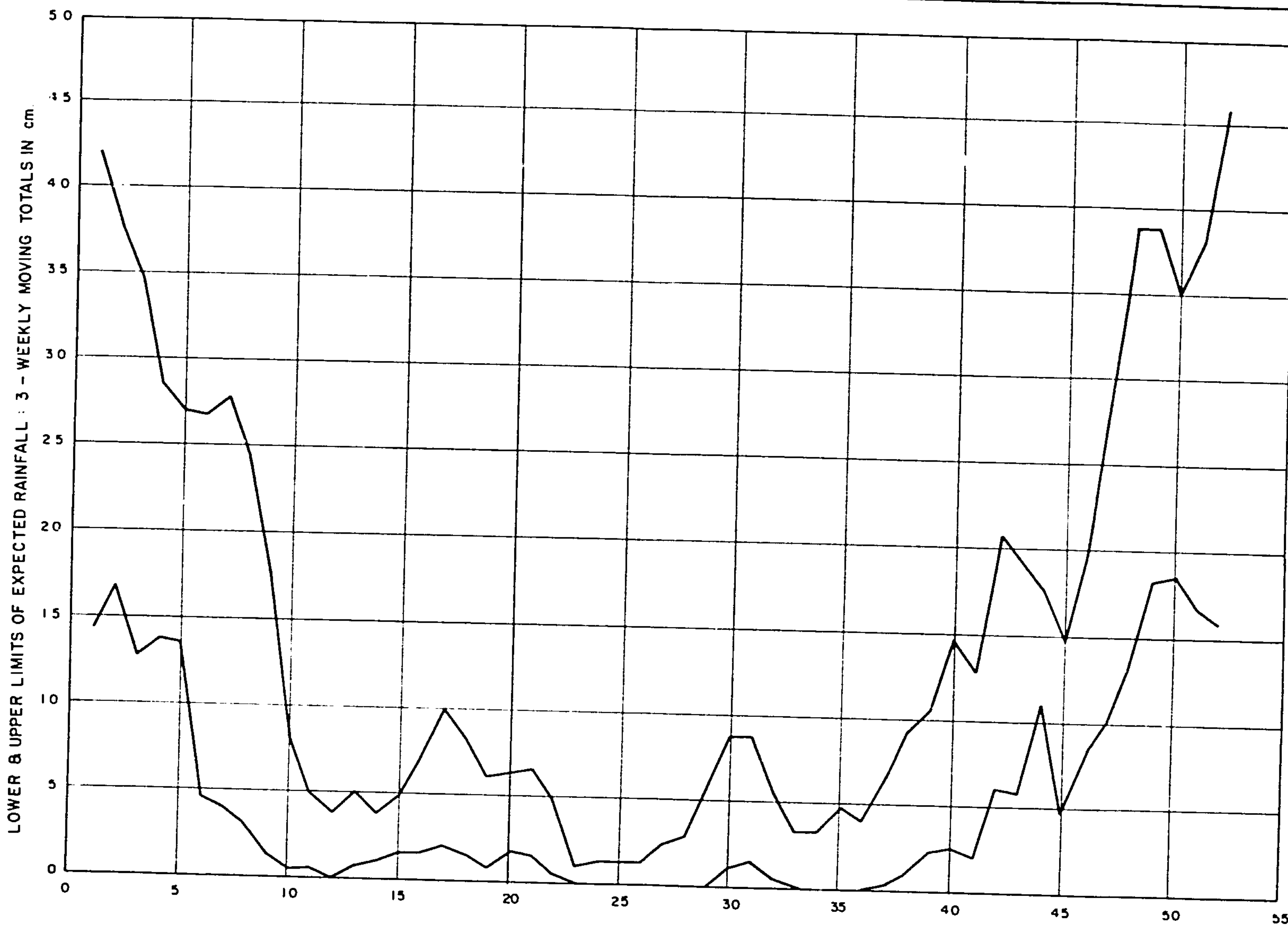
FIGURES



MINISTRY OF MAHAWELI DEVELOPMENT
MADURU OYA PROJECT FEASIBILITY STUDY
AGRO - ECOLOGICAL REGIONS

FIG. E-1

ACRES



MINISTRY OF MAHAWELI DEVELOPMENT
MADURU OYA PROJECT FEASIBILITY STUDY

FIFTY PER CENT CONFIDENCE LIMITS OF RAINFALL EXPECTANCY AT WELIKANDA, 1952-1963

FIG E-2

ACRES

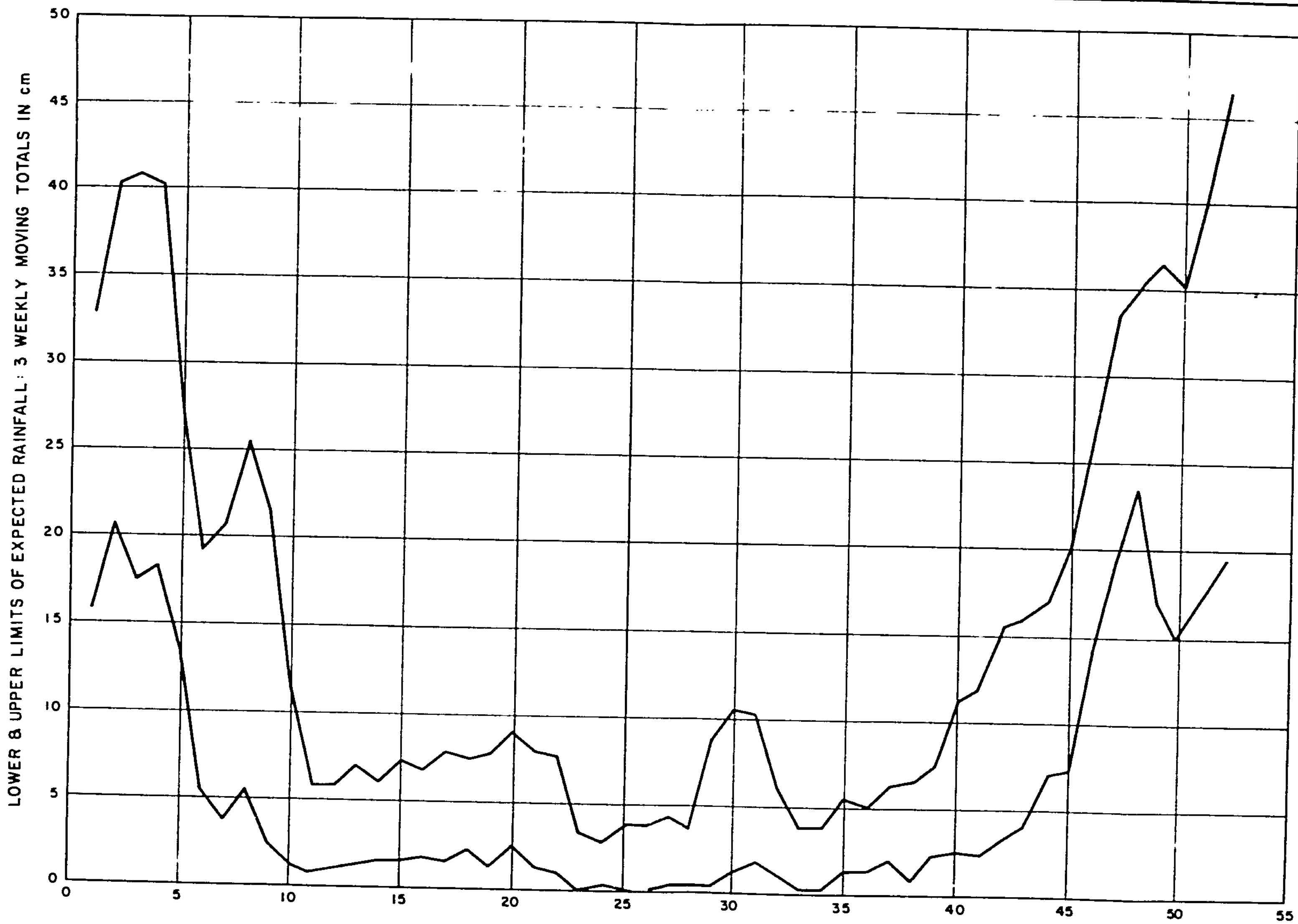


FIG E-3

MINISTRY OF MAHAWELI DEVELOPMENT

MADURU OYA PROJECT FEASIBILITY STUDY

FIFTY PER CENT CONFIDENCE LIMITS OF RAINFALL EXPECTANCY AT VAKANERI, 1952-1963

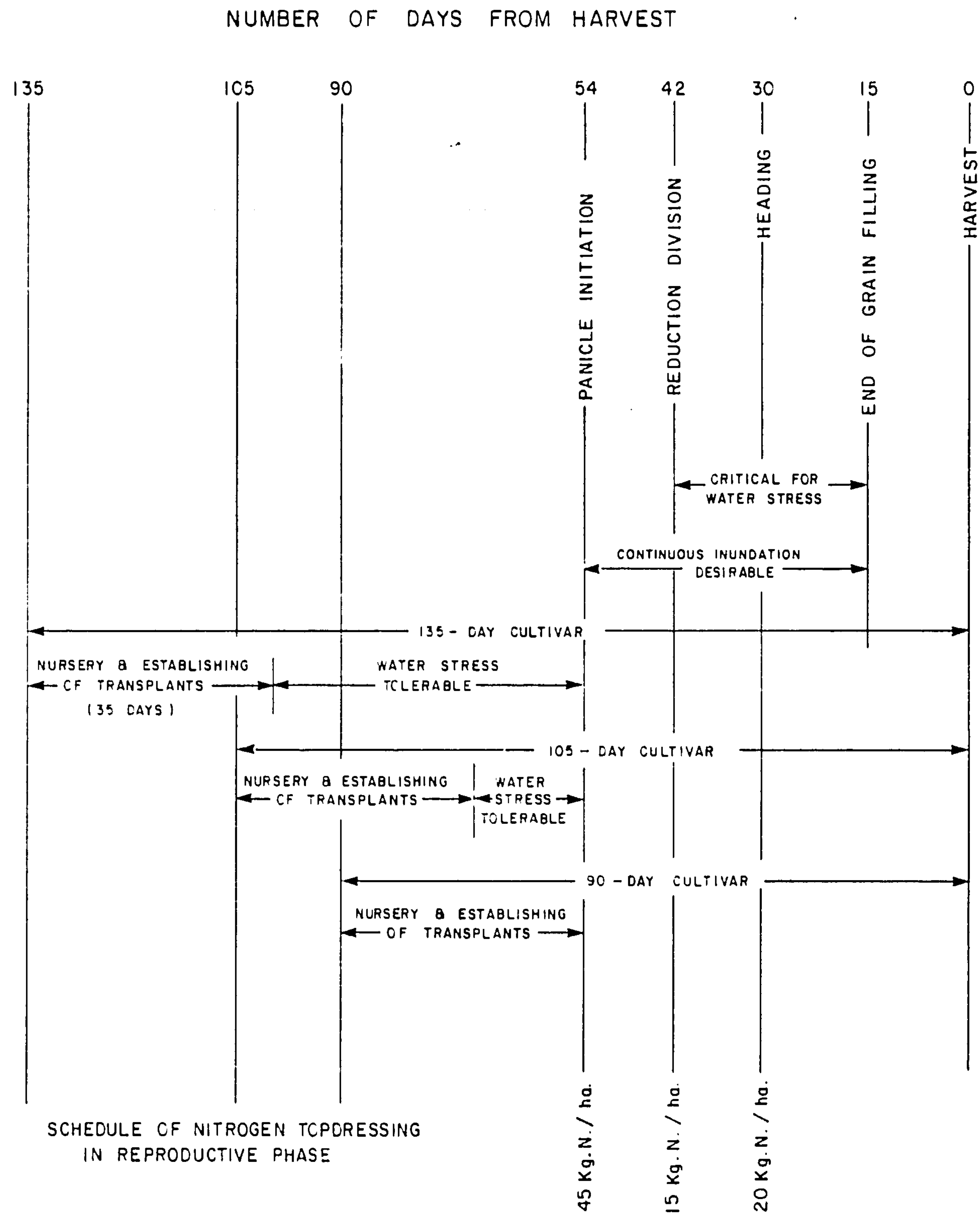
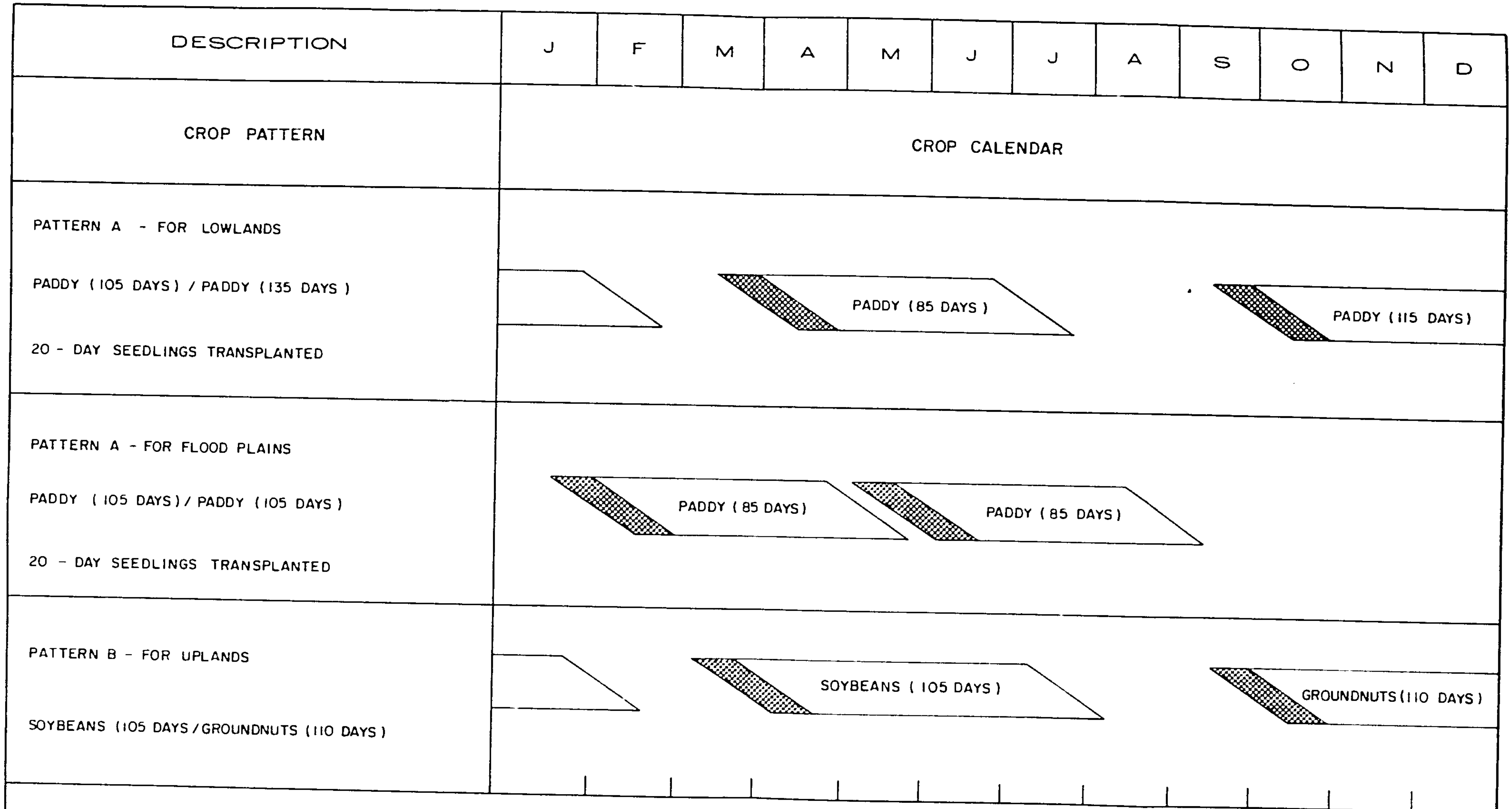


FIG. E-4

MINISTRY OF MAHAWELI DEVELOPMENT
MADURU OYA PROJECT FEASIBILITY STUDY

WATER STRESS SENSITIVITY FOR PADDY

ACRES



NOTE

▒ LAND PREPARATION

MINISTRY OF MAHAWELI DEVELOPMENT
MADURU OYA PROJECT FEASIBILITY STUDY
CROP CALENDAR

FIG E-5