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FARM POWER AND WATER USE IN THE DRY ZONE

PART- ii

JOHN FARRINGTON

FREDRICK ABEYRATNE

RESEARCH STUDY NO. 52

JULY 1982

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FARM POWER AND WATER USE IN THE DRY ZONE-(PART TWO)

JOHN FARRINGTON
FREDRICK ABEYRATNE

A Joint ARTI/Reading University Project

Research No. 52

July 1982

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F O R E W O R D

A study on Farm Power, Water Use and Criteria for Decision Taking in the dry zone was launched in 1979 as a join research project between ARTI and Reading University in UK. The main purpose of the project was to study the economic and social implications of alternative use patterns of farm power and its inter-relationsbip with water use in the small sector of Sri Lanka's dry zone.

The collection of field data was completed during the latter part of 1980. The data in respect of the 1979/80 Maha Cultivation season were analysed in depth and a report was published in October 1980 under the ARTI Research Study Series (No.43) as 'Farm Power and Water Use in the Dry Zone (Part I)'. That report however dealt with the study methodology and presented some preliminary findings. But it provided some information and suggestions of direct relevance to policy questions of whether further investment is needed in farm power, and if so in what form. The publication of an interim report was influenced by the findings in the field which showed that there was unnecessary and wasteful investments taking place in this area. We thought it was our responsibility to bring these findings to the notice of the policy makers as early as possible to avoid such expenditure in the future.

The mass of data collected in the field were analysed using the Reading University computer facilities and this final report was also written at Reading University by the joint Co-ordinators. Messrs Fredrick Abeyratne and J. Farrington. This report lay further emphasis on the

Cont'd...../2

arguments raised in the earlier documents for a change in the government policy on farm power. The authors show in several ways including in terms of social cost-benefit the need for the gradual revival of indegenous farm power sources like buffalo draught power. The report also pinpoint the need for an inter-action between the use of water and farm power.

It is hoped that this final publication and several other reports and papers published by the study team earlier will help to understand the true situation regarding the availability and utilisation of farm power in this country. Early action to evolve a more efficient system for the use of farm power would undoubtedly improve the conditions of the small farmer as well as help to increase agricultural production. Therefore, the recommendations made by the authors warrant close examination by those who are responsible for farm mechanisation policy of the country.

Mr. J Farrington, Colombo Plan Advisor to ARTI and Mr. Fredrick Abeyratne Research & Training Officer are responsible for the production of this report. Apart from these two joint co-ordinators Mr.M Ryan, a visiting researcher and Mrs. Bandara, Research & Training Officer were responsible for the supervision of the field work and initial analysis of the data. Mr. W A T Abeysekera Research & Training Officer was associated with the project in its earlier stages. My thanks are due to them for the valuable contribution they have made to focus attention on a vital area in our agricultural development programme.

Cont'd...../3

At the inception of this project it was decided that the final output would be published concurrently both by ARTI and Reading University in UK. The Reading University version is published uder the title 'Farm Power in Sri Lanka'.

I must take this opportunity to thank Professor D S Thornton of Reading University who initiated the discussions with ARTI on this project as far back as 1974. I am also thankful to Mr.Hal Metrick of the same University for his contribution to the Project as the External Consultant.

T B Subasinghe,
DIRECTOR.

AUTHORS' PREFACE

This is the final and major report of a study on Farm Power in Sri Lanka carried out between mid -1979 and early 1982. It was funded by the Overseas Development Administration, and conducted jointly between the Agrarian Research and Training Institute (Colombo) and the Department of Agricultural Economics and Management at Reading University. It is the most recent study from Reading University in a series of studies concerned with farm power in poor countries. The first of these, on Pakistan, appeared in 1972 more recently a study of farm power in Bangladesh with many parellels to the present one, appeared in 1981.

In a research study of some 2½ years' duration there inevitably arises a need to publish some hypotheses notes on methodology and preliminary findings in interim papers and reports. The volume of such published work arising directly from this study, or to which one or more of the researchers have contributed less directly is perhaps exceptionally large. One dilemma faced in the preparation of the present document was therefore particularly acute: the report should not be merely a continuation of existing lines of thought, it should stand as an intelligible entity in its own right. Yet it would be impractical to reproduce more than a fraction of the large volume of argument and data already published.

Inevitably a number of compromises had to be made where elements of previous work were thought to be particularly illuminating to arguments developed here, they were reproduced at some length. In other cases merely the appropriate reference was given. Individual readers may wish to pursue one or other aspect of the study in more depth than time or space have permitted here. For their convenience Appendix 10 contains a list of papers to which the study team have contributed in some capacity. Copies of these may be obtained by application to the sales and publications Officer, ARTI, P O Box 1522, Colombo 7

In an effort to disseminate effectively the findings of this study a Regional Seminar on Farm Power was organised aroung the main themes of the research. This took place at ARTI from October 25th - 29th, 1982. It sought to strenghen the context of the study in three dimensions, by arranging for papers to be contributed on, first, the historical and institutional setting of farm mechanisation policy in Sri Lanka, second on future sources of energy in farm production and third on the impact of farm power strategies elsewhere in the Region. A list of contributed papers is presented in Appendix 11. At the time of writing, some copies of these are available from ARTI, but the complete proceedings are to be edited by ourselves and published in 1983.

John Farrington

Fredrick Abeyratne.

ACKNOWLEDGEMENTS

Whilst the two authors were directly responsible for compiling this report, data collection and initial analysis were conducted with the assistance of two researchers whose association with the study terminated in mid-1981 - M. J. Ryan and Mrs. S. Bandara. We gratefully acknowledge their contribution in this, and Mr. Ryan's leading authorship of the ARTI Occasional Paper on Animal Draught, on which we draw heavily.

Prior to departure from Sri Lanka in June, 1981, the study team benefitted greatly from discussions with many officials of the Department of Agriculture, the Universities, the 5 Tanks Project and the FAO Study Team on Farm Power Availability, and also from informal discussion with colleagues at ARTI. We are particularly indebted to Mr. T. B. Subasinghe, the Director of ARTI, for his encouragement during the first two years of this study, and to his administrative and technical staff for their support. The staff of the Survey Department's Computer Unit in Colombo took pains to provide a service flexible enough to meet our requirements, for which we are grateful.

At Reading University, staff of the Applied Statistics Unit - especially Roger Stern, James Roger, Joan Knock and Thillai Nadesan - assisted in the implementation of RGSP2, as did staff of the Computer Unit with numerous individual programmes. In the Department of Agricultural Economics we had the benefit of comment and encouragement from Dr. D. S. Thornton, Hal Mettrick and Martin Upton. Marion Kitcher dealt capably with correspondence and numerous short papers throughout the study and managed to type the report very efficiently from a highly fragmented manuscript.

Perhaps the most significant single debt is owed to our team of field investigators, who carried a heavy and complex work load through fourteen months of difficult living conditions. To them, and to the farmers who responded to their interviewing with no guarantee of finding any advantage in the outcome, we are much indebted.

The Economic and Social Committee on Overseas Research (ESCOR) of the Overseas Development Administration generously funded this research. However, the findings presented in this publication do not necessarily correspond in any way with the official views of ODA. They are the responsibility of the authors alone.

John Farrington

Frederick Abeyratne

GLOSSARY

AI	Agriculture Instructor
ARTI	Agrarian Research and Training Institute (Colombo)
ASWEDDUMISED	Paddy land, commonly though not necessarily irrigated, which is levelled and bunded to facilitate the impounding of water.
BETHMA	From the Sinhala 'bethima' (= to share or divide). A system of (usually yala) cultivation in which allotees at the lower ends of irrigation tracts are given part of the plots allocated to farmers at the upper ends for a single season's cultivation (usually a half or third share) to reduce conveyance losses when insufficient water is available to irrigate the full command area.
BOP	Blocking-out Plan.
CHENA	Rainfed shifting cultivation, involving slash and burn techniques.
CDN	Ceylon Daily News.
CO	Cultivation Officer.
COMMAND AREA	The tract of land served by irrigation works.
KVS	Field-level Extension Worker.
LIYADDE	The smallest bunded unit within an irrigated field.
LMC	Lower Main Channel of a command area.
MAHA	The (North-East) monsoon - October-April.
NLDB	National Livestock Development Board.
RMV	Registrar of Motor Vehicles.
RVBD	River Valleys Development Board.
TIMP	Tank Irrigation Modernisation Project ('5 Tanks').
UMC	Upper Main Channel of a command area.
VEL VIDANE	Literally, 'keeper of paddy': traditionally an individual (often himself a cultivator) charged with the responsibility of ensuring fair and timely implementation of agreed irrigation schedules under village tanks. The position became redundant with burgeoning State intervention in irrigation from the 1940s. Recent attempts to revive it have concentrated on establishing a high density of vel vidanes in major irrigation schemes to provide a clearer two-way information flow between irrigation officials and farmers.
YALA	The lesser (South-West) monsoon - May-September.
YAYA	An irrigated tract of land, comprising several farms.

TABLE OF CONTENTS

		Page
Map of Sri Lanka - Showing Climatic Zones and Study Locations		i
Summary of Main Policy Related Findings		ii
Chapter 1:	INTRODUCTION	1
1.1:	The Context of Farm Mechanisation in Sri Lanka	
1.2:	Origin and Scope of the Study	
1.3:	Wider Issues in Tractorisation	
1.4:	Study Locations and Methodology	
Chapter 2:	DRAUGHT POWER AND HUMAN RESOURCES	10
2.1:	Paddy in the Agriculture Sector	
2.2:	Current Practices in Paddy Production	
2.3:	Draught Power Stocks - a national overview	
2.4:	Post-war Trends in Farm Power Policies	
2.5:	Draught Power at the Study Locations	
2.6:	Human Resources at the Study Locations	
Chapter 3:	KEY PERFORMANCE INDICATORS OF FARMS WITH VARYING DEGREES OF MECHANISATION	37
3.1:	Farm Power Use by Ownership Status	
3.2:	Farm Power Use by Type of Operation	
3.3:	Paddy Farm Size in Relation to Type of Farm Power Used	
3.4:	Farm Power Ownership and Land-use Intensity	
3.5:	Paddy Yields and Mechanisation	
Chapter 4:	MECHANISATION AND LABOUR	78
4.1:	Effects of Mechanisation on Labour Use in Farm Operations	
4.2:	Effect of Mechanisation on Labour Use in Non-farming Activities	
4.3:	Employment in Activities Directly Related to the Power Source	
4.4:	The Overall Impact of Tractorisation on Labour Use	
Chapter 5:	THE DISTRIBUTIONAL IMPACT OF MECHANISATION	100
5.1:	Patterns of Income, Indebtedness and Draught Power Control - Historical Perspective	
5.2:	Income and Expenditure Patterns of Non-owners	
5.3:	Income and Expenditure Patterns of Owners	
Chapter 6:	FARM POWER AND WATER USE: PERFORMANCE AND PROSPECTS	110
6.1:	The Cost and Benefits of Small Farm Mechanisation in Sri Lanka: Some Exploratory Calculations	
6.2:	The Scope for Increasing Tractor Use-Efficiency	

Chapter 6 (Continued) — Page

6.3: The Scope for More Efficient Use of Draught Power
6.4: Interactions between the Use of Farm Power and Water Use in Major Irrigation Schemes: Future Prospects

Chapter 7: CONCLUSIONS AND POLICY RECOMMENDATIONS 142

7.1: Characteristics of Draught Power Ownership and Use
7.2: Tractorisation and Agricultural Production
7.3: Tractorisation and Labour
7.4: Tractorisation and the Distribution of Income and Wealth
7.5: The Social Costs and Benefits of Mechanisation
7.6: The Prospects for Increasing Farm Power Efficiency
7.7: Recommendations

APPENDICES:

1: Field Survey Methodology 157

2: A Revised Calculation of Estimated Tillage Capacity of the Farm Power Stock Over Time 168
2.1: Policy Options in Sri Lanka
2.2: Availability for Farm Work in Relation to Family Size.

3: A Note on the Characteristics of Farm Survey Data Analysed in Chapter 3 178
3.1: Size of Paddy Plot by Type of Farm Power Used
3.2: The Relationship between Technologies and Work Requirements across Operations
3.3: Work Rates by Power Type - An Alternative Estimate
3.4: Tractor Use, Water Management and the Timing of Cultivation
3.5: Multivariate Analysis of Yields - Explanatory Notes
3.6: Field Experiments with 4wt and 2wt in Sri Lanka

4: Mechanisation and Labour - Supplementary Material 189
4.1: Labour Inputs for Mechanised Operations
4.2: Mechanisms of Labour Displacement
4.3: The Role of Seasonally Migrant Labour at the Study Locations

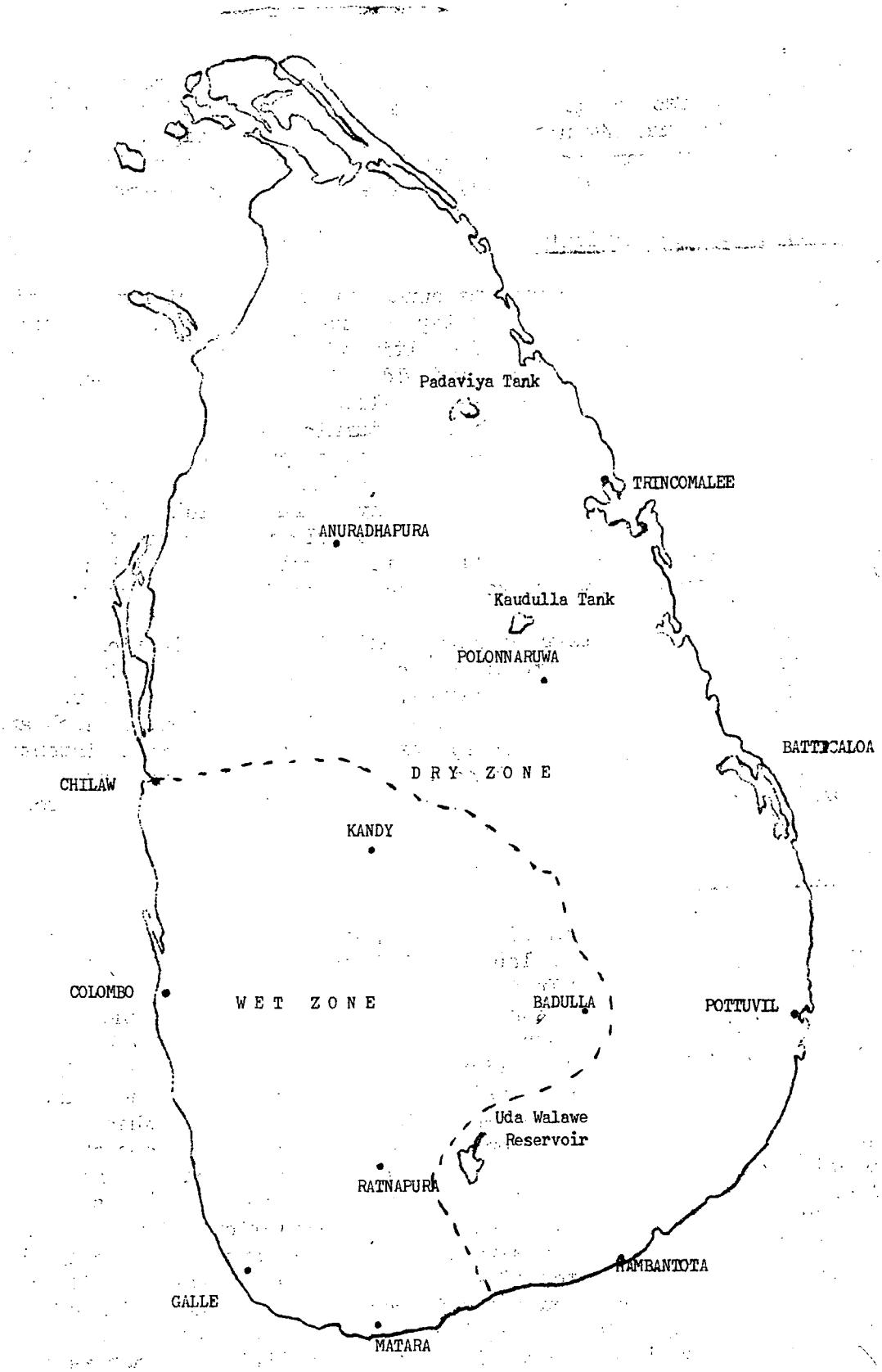
5: Incomes and Wealth Among Owners and Non-owners 195
5.1: Income and Expenditure Patterns - Non-owner Sample
5.2: Income and Expenditure Patterns - Owner Sample
5.3: Stability of Incomes
5.4: Farm Power and the Accumulation of Wealth
5.5: Assumptions Underlying the Calculation of Annual Capital Charges for 4wt and 2wt
5.6: Methodology Adopted in the Calculation of Gross Revenue from Draught Power Operations

APPENDICES (Continued)

		Page
6:	Supporting Material on the Operating Costs and Performance of Tractors	227
6.1:	The Subsidy on Diesel Fuel	
6.2:	The Costs and Benefits of Mechanisation: Exploratory Calculations	
6.3:	Tractor Use by Age and Method of Purchase: Seasonal Use Profiles	
7:	Fertiliser Recommendation for the Dry Zone	239
8:	Space and the Generation of Socio-Economic Inequality in Sri Lanka's Irrigation Schemes	240
9:	Financial and Economic Estimates of Land Preparation and Threshing Costs by Alternative Methods	256
10:	Reports and Papers to which the Research Team has contributed	261
11:	Papers Presented at the Regional Seminar on Farm Power, ARTI, Colombo, 25th-29th October 1982	263

REFERENCES 264

MAP 1: MAP OF SRI LANKA SHOWING CLIMATIC ZONES AND STUDY LOCATIONS



SUMMARY OF MAIN POLICY-RELATED FINDINGS FROM ARTI/READING UNIVERSITY STUDY ON FARM POWER AND WATER USE IN THE DRY ZONE OF SRI LANKA

This study obtained data on the patterns of farm power use and on agricultural resource productivity from samples of 220 owners of tractors and buffaloes, and 240 non-owners at three major irrigation schemes in the Dry Zone. Data were collected by intensive frequent-visit methods over 14 months, embracing the 1979-80 maha and 1980 yala seasons.

Farm size and productivity

Farms on which tractors are owned and used in Sri Lankan irrigation schemes are small, rarely exceeding 6 acres of paddy and most commonly in the 2-5 acres range, with little cultivation of non-irrigated crops. More important, the bunded paddy fields within which even 4-wheel tractors are constrained to plough are very small, averaging 0.1 acre, with high losses in efficiency through frequent turning and reversing. Comparisons between owners and non-owners of draught power suggest that tractor use has not improved the timing of paddy cultivation, nor has it contributed towards an increased cropping intensity of paddy. Paddy yields, whilst generally higher among tractor owners, are attributable to a combination of favourable circumstances (reliable irrigation water supplies) and high investment (fertiliser, transplanting) and not to tractorisation as such.

Tractors show a clear advantage only in the cultivation of large expanses of rainfed land which are not commonly available in the immediate vicinity of major irrigation schemes. These can be 'opened up' more rapidly with tractors than would be the case with traditional slash and burn techniques, and have better prospects of increased cropping intensity through reduced fallow, though no yield advantage is apparent. Only a minority of our sample of tractor owners, however, engaged in such cultivation.

Labour utilisation

The average farm that hired in a 4-wheel tractor for land preparation and threshing used some 12 labour days/acre per season less than a farm using animal draught. In the case of 2-wheel tractors, the difference was some 6 days/acre (for land preparation only). The general pattern, however, was for some two-thirds of this displacement to take the form of family labour. The introduction of a single 4-wheel tractor in place of intensive buffalo husbandry systems is estimated to displace almost 1,000 labour days/year, the bulk of which is family labour. When substituted for extensive buffalo management systems, it displaces some 500 days/year, comprising family and hired labour in equal proportions. The substitution of one 2-wheel tractor into the two systems involves the loss of some 400 and 250 days respectively. Whilst the distributional impact of labour effects is therefore not as severe as it might have been if only the poorer (wage-labour) sector of the community were displaced, it appears to involve economic loss through the increased under-utilisation of productive resources: family labour among those hiring in tractors does not appear to be re-deployed into alternative economic activities, whereas hired labour under current conditions in the sparsely populated Dry Zone might be willing and able to find alternative work. This labour displacement

pattern differs markedly from that anticipated by policy makers in their early advocacy of mechanisation: large volumes of hired labour are still required in spite of tractorisation. Much of the hired labour demand is met by seasonal migration from the Wet Zone, and official support for migration in earlier times would have been a more profitable (partial) substitute for mechanisation.

Incomes and wealth

The annual net cash incomes of tractor owners were higher than those of non-owners by a factor of sixteen. Over 30% of this difference was attributable directly to tractor operations and a portion of the remainder is indirectly attributable. Tractorisation marks a significant increase in the monetisation of the small farm economy: hire charges must commonly be paid in cash at the time of hire, whereas payments in kind deferred to the end of season are still prevalent in buffalo hire. This effect contributes to increased indebtedness since it coincides with a period of low cash reserves among farmers. Profits from tractor operations are 20-25% of current capital value in two of the three locations surveyed, but have been over 50% in earlier periods. They are ploughed back by some tractor owners into retailing, processing and transport activities, concentrating the consolidation of local economic power into the hands of a few individuals.

The widespread use of tractors in times of rising fuel prices, coupled with the strong position of tractors in the draught hire market, has allowed them to act as market leaders in setting hire charges. Buffalo owners, who have generally increased their hire charges in line with tractor rates, have reaped much of the additional income as economic rent, with the general result of a shift in the terms of trade against those who do not own draught power.

Mechanisation and the efficiency of water use

The use of tractors has done nothing to improve the efficiency of water use over the last 30 years in major irrigation, and is unlikely to do so for the future under current water management practices. Tractorisation is neither necessary nor sufficient to improve water use efficiency: given a commitment to water economy in the irrigation administration, major advances can be made through the installation of appropriate regulators and through a detailed information network essential to the fine tuning of an irrigation system. Further economies can be made by the organised staggering of cultivation, so that the draught power available for hire is first concentrated in one part of a command area, and then in the other. Only in those strategies requiring early maha cultivation on pre-monsoon rains, followed by the use of irrigation as a supplement to rainfall, is a significant productive effect likely to be attributable to 4-wheel tractors. These strategies, however, require an exceptional degree of co-ordination and supervision, and seem unlikely to make even moderate progress. Nor are they appropriate for all major irrigation schemes. Tractors are most likely to achieve strong productive effects in the early tilling of purely rainfed lands. Hitherto, this possibility has been exploited only on a limited scale.

Costs and benefits

Two factors have combined to make tractorisation highly profitable to the individual owner: a variety of State subsidies and other official support measures have been offered over the last three decades and tractorisation has permitted a redistribution of economic opportunities, within and outside agriculture, in favour of tractor owners. At the national level, however, initial calculations indicate that the policy of promoting 4-wheel tractor use in the period 1953-79 has generated a net loss to the economy of some Rs.4,000m. Only approximately 70% of purchase and running costs have been recouped through benefits in agriculture and transport. For costs to be fully recouped, benefits would need to have been some 50% higher than estimated, with no cost increase. For 2wt in 1970-79, only approximately one third of costs were recovered by benefits.

Summary of recommendations

(i) That some limited role for tractors in agriculture and transport exists, but would require a national tractor fleet far smaller than the present one. Future imports of tractors should therefore be severely restricted, preferably through the imposition of an import duty, since, on past experience, a quota may be open to abuse.

(ii) If net benefits are to be obtained from a diminished tractor stock, use intensities will have to be higher than at present, and the proportion of directly net productive work (as opposed to that involing merely the substitution of tractors for animals) will have to be higher. Opportunities for increased productivity lie in early tilling under rainfed conditions, and in off-season transport. Official assistance to increase the supply of these opportunities appears necessary.

(iii) For the bulk of tillage operations in which tractors are currently involved, a (socially) less expensive and more equitable alternative exists in the broad-based ownership of small herds of draught animals. It is recognised that a return to animal draught may be difficult to accept in some areas and for some farmers. The national costs of not doing so, however, are high, and evidence from some areas in the present study indicate aspirations for the ownership of animals but correspondingly weak, or non-existent, institutions through which they may be purchased. Official assistance through credit programmes, breeding, calf-rearing, and the re-location of working animals is therefore necessary.

(iv) In many parts of the Dry Zone, herds of draught animals are large and the number of owners correspondingly small. This ownership pattern is accompanied by low levels of husbandry, extensive grazing and low use-levels inimicable to the high land use intensities implicit in the current large-scale development of major irrigation. The widespread ownership of small herds (one or two pairs) of draught animals following the pattern observed at Kaudulla, should therefore be pursued as the more desirable of these alternatives.

(v) Widespread discrepancies exist between those located at the upper and lower ends of major irrigation schemes in levels of income and wealth. The ownership of tractors is also heavily biased towards the top ends. Strategies developed to expand the role of animal draught should therefore attempt partly to redress in favour of the tail ender the currently adverse bias of resource access opportunities.

(vi) Whilst draught animals might initially be fed (as currently in a few parts of the Dry Zone) on grass cut from verges and reservations, for the medium term an officially sponsored strategy of promoting low cost feed of adequate protein and calorific content from both crop residues and from fodder crops grown on land of low opportunity cost needs to be pursued, along with appropriate extension and training.

(vii) With increasing emphasis on the need to conserve irrigation water through the cultivation of non-paddy crops in yala and, in land preparation, through efforts at dry or semi wet ploughing, strategies to encourage a shift in the composition of animal draught herds away from water buffalo and towards bullocks might usefully be considered. These work at a faster pace than buffalo, require fewer rest periods, are not dependent on water for 'wallowing' and can conveniently be used in haulage. Their introduction requires careful monitoring, however, since their feed requirements are traditionally regarded as more exacting and their acceptance for field work may depend upon a change in socio-cultural attitudes in certain areas.

(viii) The search for improved water efficiency both generally and with particular reference to land preparation, should, in the following order of priority, attempt:

a) to increase among those responsible for scheme level irrigation administration the awareness that on-farm water use is a major and legitimate area of their concern, and to give farmers greater confidence in the permanence and impartiality of their concern;
b) to introduce the necessary physical structures, information network and procedures essential to the finely regulated supply of water to distributory and field channels;
c) to promote an organised staggering of cultivation so that draught and labour resources can be concentrated in one part of an irrigation scheme and then on the other;
d) to discover methods of making more efficient use of early monsoon rains which do not involve the severe income distribution penalties of heavy inputs of 4-wheel tractors. These might, in particular, involve ploughing on the soil moisture residual from the previous season's crop, a practice urgently in need of field research and demonstration.

CHAPTER 1 - INTRODUCTION

1.1: The context of farm mechanisation in Sri Lanka

During its early history, Sri Lanka enjoyed centuries of surplus in the production of its staple food - rice. Skills in hydraulic engineering and agriculture provided the basis for a wealthy, cultured and disciplined social order which flourished in the Anuradhapura and Polonnaruwa kingdoms of the Dry Zone (Map 1) from the second to the thirteenth century AD. The decline of these civilisations and the decay of the irrigation works on which they depended was followed by a shift of economic and political activity to the wetter parts of the country. Following the advent of the British administration, large areas of land were cleared for estate crops (initially coffee, subsequently tea and rubber) and the trans-shipment of large numbers of Indian labourers in the late nineteenth century to work on tea estates increased the demand for food but simultaneously reduced the potential area for its cultivation. The resultant deficits in rice production had to be met by food imports, placing[1] a heavy burden on foreign exchange resources even down to very recent times.

Initiatives to reduce Sri Lanka's dependence on external supplies of food, first taken in the second half of the nineteenth century, were intensified by recurrent international political and economic crises (the World Wars; the Depression of the 1930's) in the twentieth century. These initatives were based on the premise that population pressures in the Wet Zone imposed severe limits on the scope for expanded food production there; greater potential lay in the reconstruction of ancient gravity-fed irrigation works in the Dry Zone and the resettlement of population from Wet to Dry Zones.[2]

Attempts in the early twentieth century to develop Dry Zone resources involved the allocation of land to private companies, to members of the professional classes and to peasant cultivators. They were frustrated by malaria and by poor communications, and were largely unsuccessful.[3] It was only with the measure of malaria control achievable through insecticide spraying after 1945 that the potential of the legislative and financial provisions[4] promulgated during the 1930s to promote peasant colonisation could be realised. By 1953 118,438 acres of land under major irrigation

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[1] Between 1857 and 1921 the population of Sri Lanka rose from 2.4 million to 5.3 million persons, whereas the area under rice during the same period increased by only one-third. Imports of rice rose from 908,779 bushells per year on average between 1837-41 to an annual average of 5,659,041 bushells in 1882-86 (de Silva (Ed), 1973, p. 150 ff; Snodgrass, 1966, p.45 ff).

[2] For a detailed discussion of the pressures and motives underlying this 'colonisation' policy, see Farmer, 1957, esp. ch. 5-7.

[3] Farmer, op. cit, ch. 6.

[4] See especially the Land Development Ordinance of 1935, and D. S. Senanayake's Executive Committee Report on "Aided Land Colonisation" of 23rd February, 1939.

schemes[1] had been allotted to 16,532 peasants, the acreage totalling 401,626 acres in 1967 and 564,328 in 1979.[2] By 1979, the 180 major irrigation schemes accounted for 35% of the national asweddumised[3] acreage and their development had become synonymous with peasant re-settlement in the Dry Zone.

The decision to expand food production in the Dry Zone was faced with numerous obstacles, many of them imposed by natural conditions within the Zone. The problem of malaria, still endemic in the Dry Zone but now eradicated elsewhere, has already been mentioned. Other difficulties impinge directly on agricultural production. Perhaps the most important is that of starting the cultivation season sufficiently early to allow the growing period to coincide with that of maximum rainfall. In the Wet Zone, from which the bulk of colonists originate, rainfall in each of the two monsoons (maha, from October to February, and yala from May to July) is heavy and regular enough to permit paddy cultivation to start with the first rains and to be fed by supplementary irrigation as required throughout the season. In the Dry Zone, by contrast, the paddy cultivation calendar cannot easily be made to coincide with the monsoon pattern.[4] Rainfall is smaller in quantity and less regular in distribution. Soils are also harder and more difficult to work at the end of the long dry season. Even if land could be prepared with the available draught power on the first rains, farmers would be running some risk by establishing crops to be fed only by the available rainfall during the several weeks necessary for the water levels in irrigation reservoirs to rise.[5] The security-oriented strategy widely adopted, therefore, is to rely on irrigation not only as the main source of water during crop growth, but also as a means of softening the soil prior to cultivation.[6] The delays inherent in this strategy mean that the bulk of seasonal rainfall has occurred before the crop is planted (Fig. 1.1). In this less secure production environment, farmers depend more heavily on irrigation, and, since a single source of irrigation water is shared by many farmers, they are also heavily dependent on the actions of each other. The potential advantage for any individual in cultivating early in the main (maha) season lies in the quantity of stored water he can thereby save to assist in yala cultivation. If his fellow-farmers delay cultivation in order to be sure of a maha crop, the cultivation season becomes staggered, tank water issues extended, and the volume of stored water that could be carried over correspondingly reduced.

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[1] i.e. exceeding 2,000 acres comand area.

[2] Farmer, op. cit. p. 165, and Department of Census and Statistics, 1975, p.51.

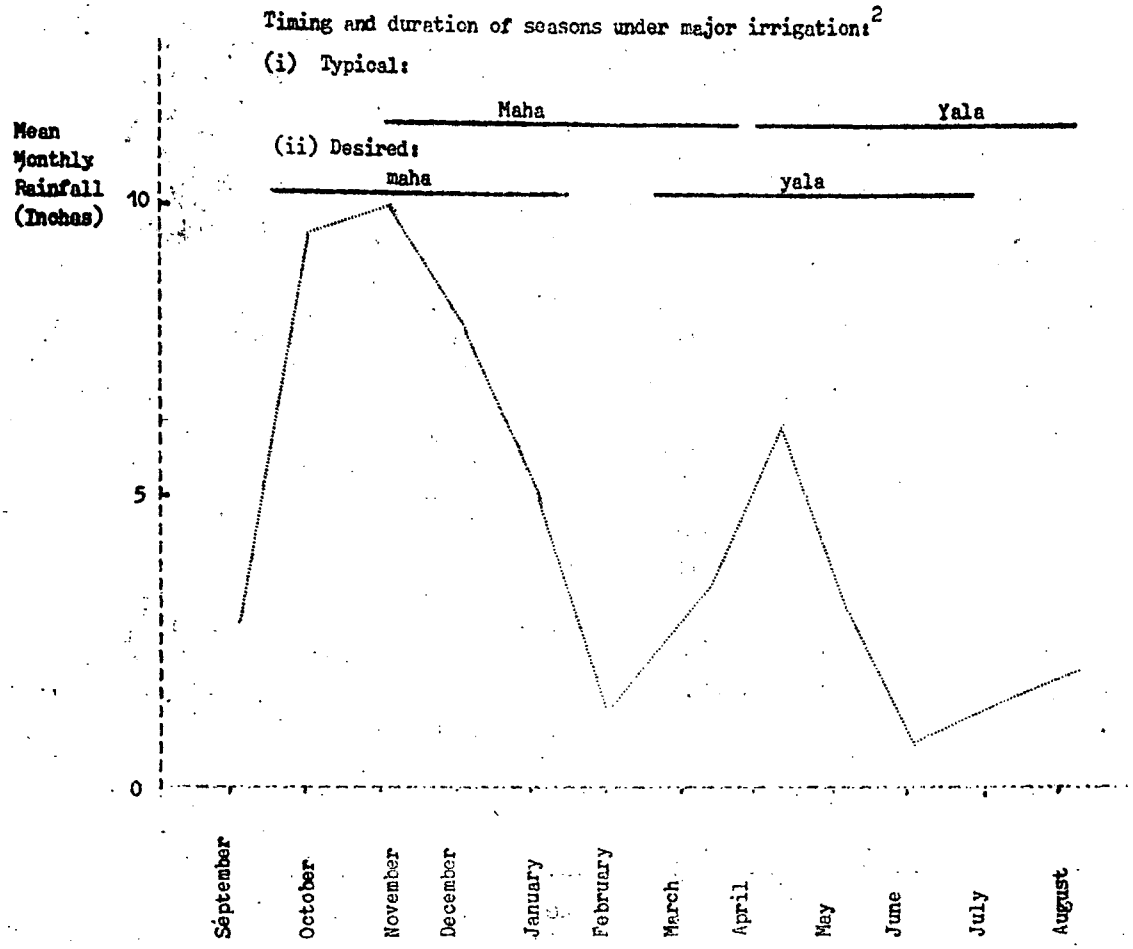
[3] See Glossary.

[4] Paddy cultivation under irrigation, with its strong cultural roots, represents almost the sole form of settled agriculture in the Sinhala Dry Zone. Small acreages of rainfed paddy, coarse grains and legumes are grown under shifting cultivation, but returns are low, and attempts to introduce potentially more profitable systems of rainfed farming have not been successful.

[5] The factors traditionally considered in deciding when to start paddy cultivation are discussed by Leach (1961).

[6] Records at the Irrigation Engineer's Office at one of our study locations (Padaviya) indicate that in recent years 15%-30% of total seasonal irrigation water issue has been used for softening the soil prior to planting. It has therefore had no direct productive effect on crop growth.

FIGURE 1.1: MEAN MONTHLY RAINFALL RECORDED AT MAHA ILLUPPALLAMA RESEARCH STATION (ANURADHAPURA DISTRICT)[1]



Notes:

1. Averaged over the years 1936-1979.
2. The 'typical' and 'desired' timing and during of seasons is highly stylised, but serves to emphasise the late start and long duration of the seasons (also the risk of overlap between the seasons in March-April) under typical current practice compared with timings which would be optimal from the point of view of rainfall distribution.
   The 'desired' pattern represents only one of several possible options; another involves the planting of a mainly rainfed short duration paddy crop in maha, followed immediately by a (January-planted) longer duration fully irrigated 'inter-season' paddy crop, with the possibility of a vegetable crop in May-September on any remaining soil moisture or irrigation water. Elements of this second option have been researched recently both at Walagambahuwa (a minor tank under the IRRI / USAID Cropping Systems Project) and at Mahakandarawa (under the TIMP).

A system of pricing water according to the quantity consumed on individual farms would no doubt discourage excess water consumption and press farmers towards an earlier and more synchronised cultivation. But it has proved physically impossible in Sri Lanka's irrigation schemes to supply water to an individual farmer in such a way that others cannot obtain access to it.[1] The illicit tapping of channels is rife, as is interference with water control and measuring structures. Thus, it has proved impossible to charge each farmer according to the volume of water he consumes,[2] and farmers' perceptions of the costs of inefficient use of irrigation water remain far below the real cost to the national economy. Officially-sponsored measures have therefore been taken to bring forward the agricultural calendar and reduce the degree of staggering in order to conserve irrigation water. These have been largely technological in character. In particular, they have relied on the extensive use of tractors in colonisation schemes with the aim of permitting early and synchronised land preparation without the need for soil to be softened by either rainfall or by an issue of irrigation water.

In large measure, it is the performance of these strategies with which the present study is concerned. A review of this kind is urgently necessary for three main reasons: the indications are that the potential of tractorisation for advancing and synchronising the agricultural calendar has not been realised;[3] the rise in fossil fuel prices since 1973 and the high rates of inflation in western Europe have meant that the cost to the Sri Lankan economy of importing and using tractors has increased substantially since 1970,[4] and the search for alternative strategies thus becomes all the more urgent; finally, Sri Lanka is on the threshold of a most ambitious expansion of Dry Zone colonisation through major irrigation schemes,[5] so that the prospect that such a review would create of redesigning draught power and cropping strategies appears particularly opportune.

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[1] However, it is worth noting the pipeline irrigation experiments in Anuradhapura district conducted by Merriam (1980) and criticism of them by Moore (1980a).

[2] Not only has it proved impossible to charge farmers pro rata for the water they consume, legislative provisions for prosecuting those who illicitly appropriate water have proved impossible to implement successfully (see Moore, 1980a, on the Irrigation Ordinance).

[3] In e.g. Carr, 1975; Sri Lanka/IRRI/USAID Cropping Systems Project (personal communication).

[4] The most popular model of 4wt cost Rs.29,000 in 1972, Rs.45,000 in 1975 and Rs.165,000 in 1981 at current prices. The rate of internal inflation is difficult to estimate in Sri Lanka (see Ranaweera, 1978) but prices appear unlikely to have risen by more than a factor of 3.5 since 1972. More than one-third of the price increase therefore cannot be explained by inflation, and represents a real cost increase.

[5] Especially the Mahaweli Development Project (UNDP/FAO, 1969) which was initially conceived to provide irrigation to uncultivated land and to supplement the water resources of existing schemes, to a total of 900,000 acres over a 30-year development period. The targets were reduced with the 'acceleration' of the programme following the 1977 General Election, and with the realisation that initial (low) estimates of paddy water consumption were over-optimistic, (Iriyagolle, 1978). However, it remains by far the country's most ambitious development project.

1.2: Origin and Scope of the Study

The Agrarian Research and Training Institute in Colombo and the Department of Agricultural Economics at the University of Reading (UK), became increasingly aware in late 1978 of the need for research to assist the administration in farm power planning for Dry Zone colonisation schemes. An early review of literature[1] revealed that the data available in existing sources provided an inadequate base for policy decisions, and financial support was obtained for a comprehensive field study of the current use-patterns of draught power and their effects in Dry Zone colonisation schemes.

This report presents the findings of the study. It also brings together information already published in a number of preliminary reports.[2] Its structure is as follows.

In the remainder of this Introduction the speculative issues surrounding small farm mechanisation[3] are discussed, and a brief summary is given of the field survey methodology and of the features of the study locations.

Chapter 2 attempts to provide a perspective on the historical policy trend and on current patterns of resource allocation in agriculture: the changing trends in government policy towards mechanisation since the 1950s are reviewed. Statistical background is provided by a summary of the changing size and composition of the national draught power stock in relation to the development of smallholder agriculture. Current practices in paddy production and their interface with alternative farm power technologies are reviewed. In the second part of the chapter, the particular distributions of human, animal and mechanised draught resources at the study locations are discussed.

In Chapter 3 we turn from the stock of draught power within its current and historical context to sample data on the ways in which power is used and its impact on crop production. This Chapter examines the use-patterns of draught power by crop operations and by certain characteristics of the sample farmers chosen to reflect their access to productive resources. Attention is given to the notion that mechanisation may be particularly profitable on larger farms, and to the possibility of positive causal links between the degree of mechanisation and land-use intensity and between mechanisation and crop yields.

In Chapter 4, the impact of mechanisation on labour-use, directly through displacement from cropping activities, and indirectly, through the creation or destruction of job-opportunities outside agriculture, is discussed. Chapter 5 examines the role of access opportunities - to draught power and to other productive resources - in generating personal incomes and wealth. Both the overall size of incomes and the extent of their seasonal fluctuation are examined.

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[1] Farrington & Abeysekera, 1979.

[2] The most comprehensive of which is Farrington et al, 1980a, but for a full listing, see Appendix 10.

[3] Gill (1981), Ch. 1, has dispelled some of the semantic confusion surrounding the concept of mechanisation. We shall follow him in applying the generic term 'tractor' to both two-axle tractors and single-axle power tillers, but in accordance with common usage in Sri Lanka and with our own earlier reports, refer to the former as '4-wheel tractors' (henceforth, 4wt) and to the latter as '2-wheel tractors' (2wt).

In chapter 6 the various strands of argument developed in proceeding chapers are drawn together. Both positive and negative effects of mechanisation are quantified in a preliminary way, and a Social cost Benefit Analysis of an exploratory character is attempted.

1.3 Wider Issues in Tractorisation

The dilemmas emerging in the search for appropriat e types and levels of mechanisation in Sri Lanka differ in some respects from those commonly faced in the region as a whole. They have already been reviewed against the available published and unpublished information by Farrington and Abeysekara (1979). Since however, they are the basic source of hypotheses for the empirical analysis that follows, it is worth summarising the main issues again here.

Binswanger (1978) reviewing a large volume of empirical work on tractorisation in South Asia, re-casts much of the debate into a single question: do tractors merely substitute for animal draught achieving no more than could adequate numbers of animals, or do they make a net contribution to the type or quality of farm operations, thereby generating increases in crop production which could not be achieved by biological energy?

Any 'net contribution' may facilitate both the intensification of existing cultivation, and, in the case of Sri Lanka at least, expansion of farming into currently uncultivated lands. Either possibility arises from the potential advantages conferred by the tractor's higher specific power output and speed. These include the potential for:

i) drawing implements with a deeper soil penetration capacity with possible improvements in weed destruction, incorporation of residues and soil aeration;
ii) tilling soil which would otherwise be impossible to cultivate at the agronomically optimal time - e.g. soil which is hard and compacted prior to monsoon rains, with potential yield advantages through the better synchronisation of crop growth with the rains;
iii) faster turn-around times between crops, resulting in improvements in crop timing and cropping intensities, with the additional benefit of reducing the uncertainty associated with rainfed farming and generating an atmosphere conducive to the introduction of agronomic innovation;
iv) reducing the area of land necessarily set aside for fodder production under animal draught systems, and converting it to the production of food for human consumption;
v) reducing the costs of cultivation at farm gate prices and, depending on the shadow value of, inter alia unskilled labour and foreign exchange, possibly also at the national level.

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1 The main difference arises from the need in Sri Lanka to co-ordinate draught power and water use among hundreds (sometimes thousands) of small farmers within an irrigated colonization scheme in order to make the most efficient use of rainfall. By contrast, the need for co-ordination of this kind does not appear to be an issue in other countries within the Region (Binswanger, 1978).

2 In view of the disproportionate increase in the costs of labour and animal supervision which is to be anticipated with increasing size of holding (of Gill 1981, p 3), it might be expected that any reduction in cultivation costs at market prices would be greater on relatively large farms, a factor which no doubt contributes to the observed holding size bias in the adoption of mechanisation (of eg. Carr, 1975 P 275 ff).

The combined speed and power of tractors, apart from generating the widely postulated effects outlined in ii) and iii) above, were expected by officials in Sri Lanka to generate important cost savings at the national level through their potential for reducing consumption of irrigation water in crop production. This potential appears to have played such an important role in agricultural planning that it merits particular consideration throughout this study.

Set against these potential advantages are the possibilities:

i) that mechanisation leads to direct displacemtn of labour from cropping activities. Whether this generates involuntary unemployment depends on several factors, including:
   - the incidence of displacement on particular sectors of the work force. Evidence from a wide range of studies in the Region (Binswanger, 1978) and from recent in-depth studies of Bangladesh (Gill, 1981) and India (NCAER, 1980) demonstrate that hired (and most frequently casual) labour will bear the strongest effects. For Sri Lanka, Fieldson and Farrington (1980) have suggested that family labour inputs are more likely to be reduced. This postulate is examined in some depth in Chapter 4 above.
   - the availability of alternative employment opportunities at the same time of year within reach of those displaced. If tractors produce higher yields there may be partial compensation for the loss in employment opportunities earlier in the season, albeit at the expense of increasing the 'peakiness' of demand for hired labour. Labour displacement may also be offset by increased cropping intensity and, perhaps particularly in Sri Lanka, by the opening up of new land for agriculture at a more rapid pace than might have been the case with traditional draught systems, and by an overall increase in economic activity facilitated by the use of tractors and trailers in rural transport;

ii) that expansion of the landholdings of tractor owners, at the expense of poorer farmers who might rely on animal draught or human labour, is likely to imply a redistribution of control of land in favour of those employing labour-sparing production methods;

iii) that mechanisation will increase the incomes of larger and wealthier farmers at the expense of smaller, poorer ones. This can be expected to increase further the skewness of income and wealth distributions, with potentially undesirable social and political effects, and with an aggregate increase in demand for imported items, arising from the higher marginal propensity to consume semi-luxury imported goods commonly observed among the wealthier strata. Thus, in addition to the foreign exchange requirements of importing tractors (or components for local assembly), fuel and spares, there emerges a secondary effect through shifts in disposable incomes among groups with different expenditure patterns.

1.4. Study Locations and Methodology[1]

(i) Study Location

In order to test hypotheses suggested by the speculative issues surrounding mechanisation, three major irrigation schemes were selected as locations at which appr opriate data could be collected over a full year. Alowing for some overlap at the beginning and end of the study period, field data were collected for 14 months in all, from August, 1979, to October, 1980 embracing the main (maha season (november 1979, to March 1980), and the Yala season (April to August 1980).

The three study locations -Padaviya, Kaudulla and Uda Walawe-are widely separated geographically (Map 1) and were chosen to reflect local conditions of population pressure, irrigation water supplies, urban proximity, agrarian infrastructure and animal husbandry, which vary considerably even within the Dry Zone[2].

Padaviya is the most remote of the three locations, surrounded by secondary jungle which is now increasingly exploited for shifting ('chena') and in some parts more settled -cultivation. Its irrigation resources reconstructed in the mid 1950s after centuries of disuse, are normally adequate for some 12,500 acres of paddy in maha and approximately 4,000 acres in yala, and are drawn from a self-contained catchment of 106 square miles. Smallholder allotments comprise 3 acres of paddy and 1 acre of highland in 95% of the scheme's area, which was reduced to 2 acres and 1 acre respectively by the time the tail end tracts 12 A and 13 were developed.

Kaudulla tank, by contrast irrigated some 11,000 acres of paddy and part of the larger complex of 60,000 acres irrigated by, in all, 4 major tanks in Polonnaruwa District. Allotments, again were initially of 3 acres of paddy and 1 of highland, but the rather later commissioning of Kaudulla than Padaviya resulted in a high (approximately 50%) proportion of allotments of the smaller size (2 acres of paddy and 1 acre of highland dictated by the change in national colonisation policy in the early 1960s. Kaudulla tank has been linked to the Mahaweli river system by a canal passing via the neighbouring Minneriya tank since 1978, and now has the capacity to irrigate the command area of some 11,000 acres in both maha and yala seasons. The cultivation of paddy under neighbouring tanks on the periphery of the Kaudulla command area has reduced access to grazing land for draught animals, so that by conrast with virtually all other areas in the Sinhala Dry Zone, a system of draught animal husbandry has evolved in which herd size are sm ll (typically 2-3 adult buffalo), the ownership of draught animals is widespread and fodder is cut and transported to the animals for most of the year.

Uda Walawe reservoir was constructed to fulfil requirements for both irrigation and hydroelectricity. Construction of the Right Bank main

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[1] Gravity irrigation schemes in the Dry Zone typically involve the construction of a dam across a shallow valley. The original river course is retained to carry away any 'spill' of water f rom the tank, and to drain any excess water from the cultivated area, and the two main irrigation channels are constructed, one each along right and left slopes (viewed from the bund) of the valley, roughly parallel to the river course. The irrigated tracts ('yayas') lie between the canals and the river, whilst housing and upland allotments are constructed on land lying above the canals.

channel was started in 1963 and settlement of the areas (approximately 17,500 acres) that it had proved possible to irrigate was complete by 1973. Construction of the Left Bank main channel started in the mid 1970s and is not yet complete. Allotments throughout the Right Bank comprise 2 acres of paddy and 1 acre of highland. Economic activity in the area is influenced by the proximity of such local industries as paper and brickmaking and large-scale paddy milling. The commercial and administrative centre at Embilipitiya is much larger than its counterparts at Padaviya and Kaudulla. Draught animals are commonly kept in large herds (typically of approximately 40 head) and grazed in areas of light tree cover, many of which are designated for future agricultural development (e.g. under the Left Bank channel).

Tractors of both types (4wt and 2wt) and draught animals are employed at all three locations (and at virtually every other major irrigation scheme in the Dry Zone), though, as will become evident, in differing proportions. Common to irrigated agriculture throughout the Sinhala Dry Zone is the almost exclusive use of water buffalo for field and threshing operations. Oxen[1] are used for transport and, in the Tamil Dry Zone, for field operations. Both tractors and draught animals, following the decline of co-operatively owned tractor pools, are now owned almost entirely by private indiciduals.

(ii) Methodology

The major study objective of assessing the impact of mechanisation could be pursued adequately only by collecting data on two distinct aspects of its function, which would, in turn, require the selection of samples from two fundamentally different populations within the rural community. On the one hand, it was found necessary to assess the impact of alternative forms of draught power as hired inputs for the great majority of allottees[2] who possess no animal or mechanical draught of their own, requiring data collection from a sample of non-owners. On the other, the use patterns of draught power and their profitability could only be assessed from a sample of owners. At each location, a sample of some 80 owners, divided in roughly equal proportions among owners of 4wt, 2wt and buffalo was selected. This was complemented by the selection of 80 non-owners at each location. The main criterion governing the selection of non-owners was that their hiring-in of farm power and its effects should be analysed in the broader context of their access to productive resources, particularly to the key input of irrigation water. Pre-survey field observations indicated the parts of each command area subject to shortages of irrigation water[3] and at each location the non-owner samples were drawn from four distinct populations demarcated by the quality of their access to irrigation water.

Data were collected both by frequent visit techniques and (in the case of crop acreages) by direct measurement. The frequency of data recording varied by data type: at the highest level of frequency, daily recores were kept for tractor and buffalo use. For farm inputs, weekly totals were deemed adequate. A detailed description of survey instruments is given in Farrington et al (1980a) Chapter 2.4, and is summarised in Appendix 1 of this report.

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[1] Of both indigenous (also known as 'neat cattle' in Sri Lanka) and exotic cross-bred types.

[2] At Uda Walawe, fewer than 1% of allottees possessed animal or mechanical draught of their own; at Padaviya the proportion was 18%. Even at Kaudulla, where draught ownership was most widely distributed, only some 30% of allottees possessed power of their own(calculated from Part 1 Report,Tables8-11).

[3] Commonly the 'tail ends' of main channels, but sometimes also the lower reaches of lesser ('distributory') channels.

CHAPTER 2 - DRAUGHT POWER AND HUMAN RESOURCES

2.1. Paddy in the Agriculture Sector

The focus of attention in this report is on paddy. Its primacy as the staple food crop is unchallenged: it occupies far more land annually than all the other main smallholder crops combined (Table 2.1.1.). Some have argued that the increased demand for paddy and, to some extent, its increased acreage is not merely a function of population growth, but has been critically influenced by welfare-oriented policies which have subsidised the consumer price of rice since 1948, thus encouraging substitution of rice for root crops (cassava, yams) and for tree produce such as jakfruit and breadfruit.[1] Even with the recent reduction in such subsidies, however, the demand for rice remains high and regular self-sufficiency is likely to be reached only by the mid-1980s.[2] Of the annual area allocated to paddy, 811,223 acres (39%) were cultivated under major irrigation schemes entirely in the Dry Zone, a further 480,906 acres were grown under minor irrigation in both Wet and Dry Zones, and the remaining 798,049 acres (38%) were grown under rainfed conditions, predominantly in the Wet and Intermediate Zones.[3] For the Dry Zone, therefore, major irrigation schemes constitute the most significant form of paddy production.

Whilst they are powerful enough in themselves, these statistical factors were not the sole influence on the decision to focus this study on paddy production under major irrigation. Much of the cultivation of non-paddy smallholder crops is still under conditions of slash and burn ('chena') in the Dry Zone, so that the scope for mechanisation is negligible. Even within paddy production, the scope for mechanisation outside the Dry Zone is limited: topography in the Intermediate and Wet Zones is frequently hilly, paddy is steeply terraced and inaccessible to tractors. In the low country Wet Zone, soils are frequently boggy and prone to deep flooding, which again limits the scope for mechanisation.[4] The areas offering the most immediate opportunity for mechanisation are therefore the large contiguous areas of paddy served by major irrigation.[5] Furthermore, it is this irrigated mode of paddy cultivation for which ambitious expansion is planned

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[1] Brohier, 1975, pp. 162-3, reports that in 1974 rice which had to be imported at 75 cts per measure was sold locally at the subsidised price of 25 cts. Following the 1977 General Election, the widespread system of consumer subsidies has been largely dismantled.

[2] Central Bank, 1981, p.24.

[3] Department of Census and Statistics, 1980, pp.55-57.

[4] Pannabokke, 1967.

[5] Brohier, 1977, pp.118-122, describes large areas of the eastern coastal belt where paddy is cultivated on large (i.e. over 20 acres) farms held by absentee landlords under riverine flooding regimes with some supplementary irrigation. These constituted a prime focus of early mechanisation efforts (see Chapter 2.4) and were surveyed in a recent study of farm tractors (Carr, 1975). With the expansion of major irrigation schemes their relative significance has, however, declined.

TABLE 2.1.1: ANNUAL AREA (ACRES) UNDER PRINCIPAL CROPS

	1973	1979
1. Principally Estate Crops		
Tea	598,735	603,175
Rubber	564,818	559,932
Coconut	1,115,600	1,115,600
Sub-Total	2,279,153	2,278,707
2. Principally smallholder crops[1]		
Millet	74,625	57,328
Maize	72,154	48,185
Chillies	109,714	88,957
Red Onions	21,498	22,239
Potatoes	8,401	10,131
Cassava	284,662	132,447
Sweet Potatoes	66,471	40,278
Sub-Total[2]	637,525	390,565
Paddy	1,792,083	2,090,178
Paddy as % of all main smallholder crops by area	73.8%	84.0%

Notes: 1. Annual areas are obtained by adding maha and yala planted acreages.
2. The decline in cultivation of smallholder crops other than paddy between the two years is largely attributable to relaxation of the restrictions on their import following the 1977 General Election.

SOURCE: DEPARTMENT OF CENSUS AND STATISTICS, 1980, pp.54-5.

under the Mahaweli River Diversion Project.[1] For these several reasons, it appeared most appropriate for the present study to assess the impact of mechanisation on paddy cultivation under major irrigation schemes.

2.2: Current Practices in Paddy Production

Paddy has traditionally been the only crop grown under large-scale gravity irrigation in the Sinhala Dry Zone. Recent attempts to encourage diversification into legumes and vegetables chiefly designed to obtain higher returns to water use in yala, when water is particularly scarce, have so far met with little success.[2] Our analysis of the current impact of mechanisation is therefore necessarily conducted within the context of a paddy monocrop, although in Chapter 6 we attempt to project the study's findings forward into situations involving non-paddy crops.

[1] UNDP/FAO 1969. The project was initially conceived both to provide irrigation to uncultivated land and to supplement the water resources of existing schemes, to a total of 900,000 acres over a 30 year development period. The targets have subsequently been reduced with the 'acceleration' of the programme following the 1977 General Election. However, it remains the country's most ambitious development project.

[2] See Wijayaratne (forthcoming); Ranatunga et al. 1981, and for data from the current samples, Chapter 3.4 below.

The following brief discussion of common current practices in paddy cultivation will indicate both those operations for which some degree of mechanisation has already been adopted, and those which offer scope for mechanisation in the near future.

There are few differences in paddy cultivation techniques among the agro-ecological zones.[1] For wet cultivation, generally adopted under rain-fed conditions in the Wet Zone and under irrigation elsewhere, sufficient water is impounded in paddy plots (liyaddes) for the soil to be completely flooded. A minimum of two tillings, separated where possible by an interval of 10 days to permit decomposition of weeds beneath the standing water, is performed by one of the methods outlined in Table 2.2.1. 4-wheel tractors are universally fitted with 9-tine tillers; rotavators or mouldboard ploughs are fitted to 2-wt and buffaloes rely either on a trampling action ('mudding') to churn the soil, or on traditional (tine) or semi-mouldboard ploughs. After tilling, water levels in the liyaddes are reduced to permit levelling of the soil, using a board (poruwa) drawn by buffalo, 2-wt, or occasionally, by 4-wt or human labour. More care appears to be taken with levelling if the field is to be broadcast with (pre-germinated) paddy: fields are generally finish-levelled with a small hand-drawn board, and shallow drainage channels made. This careful attention clearly acknowledges the critical influence of water control on crop establishment in the first days after broadcasting.[2] With transplanting (approximately 25% of the national area planted annually to paddy), standing water is, where possible, left in the liyaddes from land preparation through to harvest. The contribution of impounded water to weed control is well recognised by farmers, and broadcast plots, similarly, are re-flooded as soon as the crop is established.

Subsequent operations are performed as described in Table 2.2.1. Detailed national estimates of the adoption levels of alternative cultivation methods[3] are not available. Only broad indications are possible: chemical control of weeds by spray application covers some 480,000 acres of paddy land per maha season,[4] and thus appears to be the most common method of control; for threshing, trampling by animals and the wheel action of 4wt appear equally common.

The field operations offering scope for mechanisation are principally land preparation and threshing. The use of tractors remains restricted to these, and it is difficult to envisage the application of tractor power to interculture operations where paddy is grown in mudland conditions and

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[1] But for a discussion of the geographical incidence of transplanting, see Chapter 3.4 below.

[2] For an account of the care with which fields are prepared prior to broadcasting, and of the rituals traditionally surrounding the pre-germination of the seed, see Brohier, 1975, pp.148-154.

[3] Other than in land preparation, see Table 2.3.2.

[4] Agricultural Implementation Programme, Ministry of Agricultural Development and Research, 1979-80.

TABLE 2.2.1 ALTERNATIVE POTENTIAL MECHANISATION OPTIONS FOR THE MEDIUM TERM IN DRY ZONE PADDY FARMING

Alternative Strategies/ Operation	1. 4-wheel Tractor	2. 2-wheel tractor	3. Animal Power	4. Human Power	5. Comments
Land Preparation	*	*	*	*	Options include improved implements (for 1-3), alternative frequencies, timings and sequences of tillage, alternative weedkiller application strategies, and alternative soil/water regimes. Zero tillage, minimum tillage and strip cropping are being researched for medium- long-term introduction.
Applying Fertiliser				*	Fertiliser is universally broadcast by hand. In Sinhala areas the use of organic manures, mulches, etc. is negligible.
Pest/ Disease Control				*	Chemical application by hand-operated or motorised knapsack sprayers is most common. Granular and powder formulations are also used. The value of such agronomic techniques as synchronous planting, removal of crop residues, use of resistant varieties etc. is widely recognised.
Weed Control				*	The use of animal or tractor-drawn implements specifically designed for weed control is rare. Attempts to promote hand-operated rotary weeders and improved hoes have had little success. The level of hand weeding (by uprooting) is low. The application of herbicides in a water base by hand operated or motorised knapsack sprayers is most common. The value of controlling weeds by maintaining fields in a flooded condition is recognised, as are alternative tillage strategies and, it is claimed, the avoidance of grass seed transmission through application of animal manure.
Harvesting				*	The use of hand sickles is most common. Small mechanised reapers are under trial at research stations.
Threshing	*		*	*	The wheel action of 4wt is commonly used, as is the trampling action of buffalo and oxen. In some (principally Wet Zone) areas, the trampling action of human labour is employed. The attempt to introduce pedal operated threshers is said to have failed because of its low speed and high labour requirements. Small axial-flow threshers, independently motorised or driven by 2-wt are currently on trial at research station.
Winnowing	*	*		*	The most common method involves the use of simple woven trays from which the grain is allowed to trickle, often with the height-advantage of a bamboo tripod, the debris being blown away by the breeze. Small fans mounted on 2-wt, and larger ones on the power take-off of 4-wt have become common for use when windspeed is inadequate. Such fans are also driven by pump sets and by human pedalling.
Transport	*	*	*	*	Trailers and carts are commonly attached to animals and tractors. Human labour may involve the bicycle or the headload. Water buffalo are not commonly used to draw carts. Each type tends to be specific to distances, road conditions, type of load etc. It is not uncommon for 2-wt trailers to be adopted for the transport of passengers.
Pumping					Pumping is rare is paddy production, where gravity irrigation is the norm, though common among non-paddy crops, especially in Jaffna. Internal combustion pump-sets (normally of 2" capacity) are occasionally used (illicitly) to irrigate paddy lying above the channel level. The use of electric pumps in crop production is rare, largely due to the sparse network of rural electrification and to the long distances in settlement schemes between homesteads and paddy fields. Wind-powered pumps are under investigation at the Water Resources Board. Pumps or lifting devices driven by 4-wt, 2-wt or animal power are rare.

(SOURCE: Adapted from Table 1 in Farrington et al (1980c)).

1. =4 Wheel tractor: 2.= 2 wheel tractor 3.=animal power 4.= human power
ZSOURCE: ADAPTED FROM TABLE 1 in FARRINGTON ET AL (1980).

plant spacing is irregular.[1] Field trials of motorised cutting and binding machines have been moderately successful, but given the small size of farms and liyaddes in paddy cultivation, it seems doubtful whether such operation-psecific machinery has even medium term prospects of introduction. The attempt to introduce combine harvesters in the early 1950s into paddy tracts irrigated by the Gal Oya reservoir failed on account of the boggy soil conditions, small field size and frequent obstructions (tree stumps, rocks, etc.)[2] and seems unlikely to be repeated.

Of these two principal field operations which have been mechanised to some degree, land preparation merits particularly close attention in view of the prospects already mentioned of achieving earlier and more synchronised cultivation through tractorisation. The issues to which these prospects give rise are, however, by no means clear-cut, and merit extensive consideration in the body of this report.

Basically, the gap between the planting of rainfed and of irrigated crops in the Dry Zone has led many observers, among them those responsible for the planning of farm power stocks, to conclude that more efficient use of stored water could be made by planting the crop earlier and thus permitting it to grow under predominantly rainfed conditions in its early stages. This possibility has been the subject of large-scale field trials at major tanks (e.g. Mahakandarawa, one of the 5 Tanks under the Tank Irrigation Modernisation Project) and at minor irrigation schemes (Walagambahuwa, under the Sri Lanka/IDRC/IRRI Cropping Systems Network) for several seasons. Whilst it increases the potential pay-off in terms of annual net farm revenue, the prospects of increased resource-pressure at the beginning of the season and increased riskiness of crop production, together with (at least on major irrigation schemes) its requirements of enhanced flexibility in implementation of the irrigation schedule, have prevented its spontaneous adoption.

The possibility of advancing the cropping calendar and of reducing inter-farm staggering of cultivation has a strong bearing on the demand for draught power, on the composition of the power mix and on respective returns to the various type of draught power. We shall therefore be examining hypotheses arising from these field trials in some depth in Chapter 6.

Further, the staggering of cultivation between the Wet and Dry Zones has important implications for the use-intensity of other resources. In particular, as recent research[3] has shown, important seasonal migrations of casual labour occur between Wet and Dry Zones. The role of such labour and its potential role under increased levels of mechanisation in the Dry Zone will be discussed below (Chapter 4).

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[1] On major irrigation schemes, the proportion of paddy acreage transplanted fluctuates between $\frac{1}{2}$ and $\frac{2}{3}$ and does not appear to be rising. There is no tradition of transplanting in rows in any part of the country, and efforts to introduce it have failed in view of the preferred ease and speed of random transplanting. Paddy which is not transplanted is broadcase by hand. Machines developed for row-seeding or row-transplanting under mud conditions have been beset by technical shortcomings or high cost. Moreover, since weed control is traditionally by inundation (and more recently, by chemicals), farmers do not perceive the need for planting systems which will facilitate row-weeding by simple tools or mechanised equipment. The prospects for more widespread row-planting to permit mechanical weeding therefore appear poor in the next two decades or so.

[2] Brohier, 1975, pp.148-154.

[3] Perera and Gunawardena, 1980; Crooks and Ranbanda, 1981.

2.3 Draught Power Stocks - A National Overview

In this section the attempt is made- in spite of the generally low quality of data and the need to rely heavily on assumptions to answer three broad questions.

i) In response to the question: is there currently a surplus or deficit or farm power vis-a-vis the national cultivated acreage ? Our analysis indicates a surplus.

ii) To the question: how has the availability of farm power been changing over time ?
We indicate some improvement in the ratio of power to asweddumised acreage.

iii) Finnaly, difference in the relative significance of the three main power types (4wt,2wt,buffalo) among agro-climatic zones are stressed. As suggested in our previous discussions, tractorisation emerges principally as a Dry Zone phemonenon.

These questions are now considered in turn:

1. The current tillage capacity of the farm power stock

The standing methodology of estimating farm power tillage capacities[2] displays numerous shortcomings. Whilst it may provide a very broad indicator, it ignores the possibility of utilising the existing draught stock more intensively, a prospect which appears highly relevant to the current situation in Sri Lanka. Most fundamentally, this methodology ignores the essential role of dynamic economic forces, involving local demand, supply hire-charges and operating costs in determining use-levels.

Furthermore, the quality of data on current and historical levels of the farm power stock leaves much to be desired. For instance, the Part 1 Report (Appendix v) and subsequent analysis by Ryan et al (1981) have drawn attention to the wide inconsistencies in national buffalo herd data. Tractor registrations with the Registrar of Motor Vehicles yield a convenient source of data on tractor stocks, but may provide an underestimate in that many tractors (especially 2wt) remain unregistered.[4]

With these provises in mind the attempt is made in Table 2.3.1 to estimate the stock of farm power available for agricultural work by zone. Whilst the density of 4wt is muchlower in the Wet Zone than elsewhere, that of 2wt varies little by Zone, and that of buffalo is relatively low in the Dry Zone. Of particular interest is the evidence that this table provides of the high carrying-capacity for animal draught of the densely-populated Wet and Intermediate Zones. In spite of the low availability of grazing lands, there numbers of small herds can be kept through stallfeeding with minimal grazing.

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[1] This corresponds with the size-distribution of farms by zone: in 1973 the mean area of land (paddy land highland and home garden) per holding was 1.81 acres in the wet zone, 3.01 acres in the Intermediate and 2.99 acres in the Dry Zone. (Census of Agriculture 1973). All Islandaverage holding sizes have decreased from 3.3 acres in 1947 to 2.35 acres in 1973, as a result of increasing fragmentation in wet and In Intermediate Zones, but also as a result of successive decreases during this period in the size of allotment granted to new settlers in the Dry Zone.

[2] See FAO (1980).

[3] 31% of the sample 2wt in this study were unregistered.

[4] Chapter 7 below.

TABLE 2.1.2: THE EFFECTIVE AVAILABILITY OF DRAUGHT POWER BY TYPE AND BY ZONE

		Total Supply	% available[1] for Cultivation	Effective No. of[2] Units available for Cultivation	Density per 1000 acres of Aseddumized Land
Wet Zone	Buffalo Pairs	97550	40	39020	103.2
	2 wt	2250	80	1800	4.8
	4 wt	1900	50	950	2.5
Intermediate Zone	Buffalo Pairs	103200	40	41280	157.9
	2 wt	1350	80	1080	4.1
	4 wt	1900	70	1330	5.1
Dry Zone	Buffalo Pairs	221100	40	77440	84.5
	2 wt	5400	90	4860	4.6
	4 wt	5700	80	4560	4.4
Sri Lanka	Buffalo Pairs	421850	40	84370	100.1
	2 wt	9000	86	7740	4.6
	4 wt	9500	72	6840	4.1

Note: 1. Percentages of availability for field cultivation for each power type are drawn from personal communications with the FAO Farm Power Study Team.

2. The following work-rate assumptions are used -

Buffalo: 0.30 acres per 5 hour day, 32 day land preparation season in Maha. Output per Maha is 9.6 acres per pair.

2 wheel tractor: 0.67 acres per 8 hour day, 32.5 day land preparation season in Maha. Output per Maha is 21.8 acres per unit.

4 wheel tractor: 2.0 acres per 8 hour day, 32.5 day land preparation season in Maha. Output per Maha is 65 acres per unit.

Source: Buffalo = R. N. Parker, "Tank Irrigation Modernisation Project Characteristics of Existing Tractor Operations", Jan., 1979

Tractors - Personal communication with FAO Farm Power Study Team.

Ironically, the diminishing areas of land for grazing in the Dry Zone are frequently cited as evidence of the need for tractorisation, yet grazing remains abundant by wet zone standards and only limited transition to stall feeding has taken place. The potential for wider exploitations of the dry zone's feeding resources is discussed in more detail in chapters 6 and 7.

Estimates of the zone-wise aggregate tillage capacities of the farm power stock to which this analysis leads, must be treated with some caution in view of the broad assumptions regarding availability and performance. Table 2.3.2 indicates the continuing significance of hand cultivation in the small frequently terraced plots of the wet zone. Only in the Dry Zone do tractors assume a dominant role in land preparation. The potential tillage capabilities of the respective power types presented in the second half of this table indicate, overall, a surplus of farm power equivalent to 771,448 acres of tillage capacity. The difficulties arising from an unreliable data base are immediately apparent, however: when a lower estimate of buffalo population is used, this surplus capacity is transformed into a deficit equivalent to 488,450 acres of tillage. There are strong grounds for rejecting the lower population estimate, so that

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[1] Discussed in Part 1 Report, pp 147-167

TABLE 2.3.2: TILLAGE CAPACITIES AND POWER REQUIREMENTS BY ZONE

ZONE	WET		INTERMEDIATE		DRY		SRI LANKA	
1. Asweddumised area (1978/79, acres)	377,975		261,399		1,046,226		1,685,600	
% Distribution	22.4		15.5		62.1		100.0	
2. Estimated Acreage prepared in maha 1978/79 by:	Acres	%	Acres	%	Acres	%	Acres	%
i) Hand Cultivation	152,112	44.6	16,224	6.5	48,974	5.0	217,310	13.8
ii) Buffalo	148,672	43.6	151,832	61.2	349,853	35.9	650,357	41.4
iii) Tractor	40,049	11.8	79,859	32.3	573,986	59.1	703,894	44.8
Total	340,833	100.0	247,915	100.0	982,813	100.0	1,571,561	100.0
3. Estimated maha tillage capabilities[1] in acres of:								
i) Hand Cultivation	171,415		16,858		35,733		224,006	
ii) Buffalo	374,592		396,288		849,024		1,619,904(360,000)	
iii) 2 wheel tractor	39,195		23,517		105,826		168,538	
iv) 4 wheel tractor	61,750		86,450		296,400		444,600	
Total	646,952		523,113		1,286,983		2,457,048(1,197,144)	
4. Power 'Surplus'	268,977		261,714		240,757		771,448(-488,456)	

Note: 1. The estimated maha tillage capacities incorporated an 'availability' factor which varies by Zone, according to the opportunities for off-farm employment of tractors. This factor also allows for the incapacity of buffaloes through pregnancy, disease, etc. Estimates of these factors were supplied by personal communication with the FAO Farm Power Study Team (FAO, 1980) (see Table 2.3.1). The work-rate assumptions below Table 2.3.1 were used.

SOURCES: 1 and 2 - Agricultural Implementation Programme, 1979/80, Ministry of Agricultural Development and Research,
3 - Table VI.12 above.
4 - Asweddumised area less maha tillage capacity totals.

The figures in parentheses are derived from the lower of the two official sets of buffalo population data, i.e. from Census of Agriculture data for 1961 and 1971.

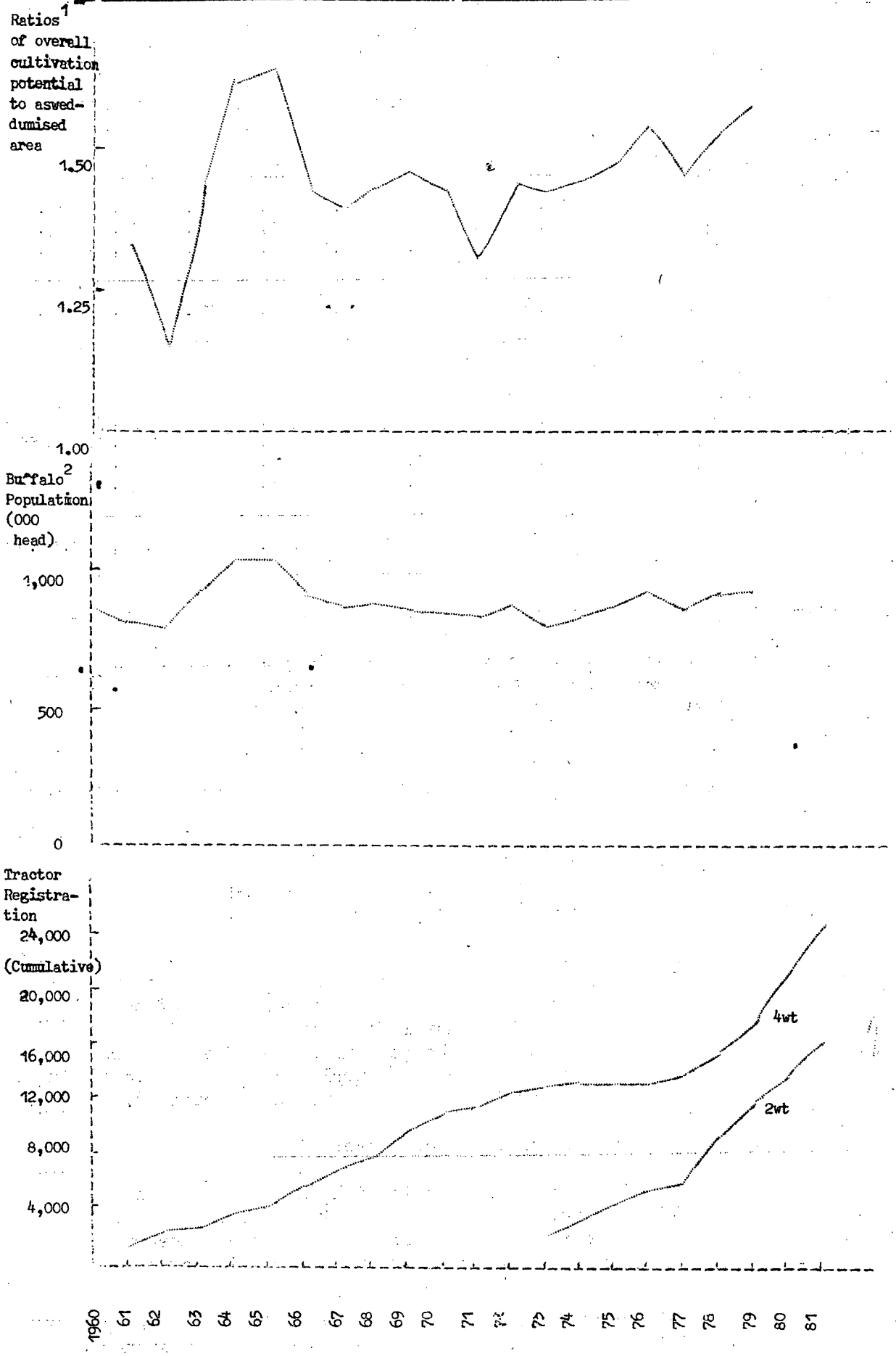
the overall indication is one of spare capacity in the draught power stock. That Sri Lanka now has more draught power than it needs is an effect of the flood of imports following the 1977 General Election, when a removal of import restrictions permitted much of the pent-up demand from the previous 7 years to be satisfied. Further evidence of surplus capacity is to be found in the low use levels of tractors in the study samples (Chapter 6).

2) Changes in the availability of farm power over time

The attempt to project the tillage potential data presented in Table 2.3.2 back into earlier time-periods is made in Figure 2.1. Again, some caution is required in view of the unreliable data and broad assumptions involved.[1] The indications are, however, that a slight improvement has

[1] A re-analysis of data using work-rate assumptions derived from the present study is attempted in Appendix 2. It does not change the substance of the arguments presented here.

FIGURE 2.1: TRENDS IN DRAUGHT POWER POPULATIONS IN RELATION TO ASWEDDUMISED ACREAGE



NOTES ON FIGURE 2.1:

1. Derived from the cumulative tractor registrations and buffalo population data, with an allowance for non-agricultural use and conventionally adopted work output rates (see Table 2.3.1). Tractors permanently withdrawn from service should, technically, be 'de-registered' but in practice this is not alwasy done by the owner, so that (especially) the working 4wt population may be overestimated here. On the other hand, many tractors (31% of 2wt in our survey) are never registered in the first place, which will tend to cause an underestimate. On balance, the data presented here seem likely to overestimate the effective draught stock in relation to asweddumised acreage. For an attempt to arrive at a more realistic absolute value of this ratio, see Appendix 2, Table A.2.1.

2. A lower estimate of buffalo population is provided by the Censuses of Agriculture in 1961 and 1971. This is rejected in favour of the higher figures for reasons discussed in the Part 1 Report, pp. 147-167.

SOURCE: Tractors: Registrar of Motor Vehicles, Colombo.

Buffalo: Annual Livestock Population Surveys of the Department of Census and Statistics.

taken place since 1960. Two qualifying points require consideration: first, the availability of 4WT for agricultural work may have been higher in earlier years than is suggested by the 72% of those in working order assumed for 1979. If this is the case, the extent of the improvement inavailability may have been overestimated. In the cost-benefit calculations in Chapter 6, for instance, it is assumed that the proportion of tractors available for agricultural work was higher (ie 90%) in the early years of mechanisation. Second, a force acting in the opposite direction is that some underestimate may have been made of the stock of tractors in working order in the latter part of this period. The findings of the 1974 Tractor Survey, on which the figure of 9,500 useable 4WT in 1979 is based, seem likely to have been an underestimates by 22% the number of 4WT registered.[1] If a similar underestimate of the number of 4WT in working order has been made, the total in 1979 may be nearer 12,000 than 9,500.

On balance, there do not appear to be strong grounds to dispute the evidence of some improvement over time in the availability of draught power, to a point where in 1979 it was more than adequate to fill the entire cultivated acreage.[2]

2.4 Post-war trends in Farm Power Policies

As data in the previous section indicated current tractor densities in Sri Lanka are high. The ratio of 4.1 4WT available[3] per 1000 acres of asweddumized land in Sri Lanka compares closely with the density observed in areas such as the Indian Punjab which have long been associated with highly mechanised farming.[4] This high density is not merely a product of the free market forces of demand and supply: it is attributable in large measure to deliberate government intervention in the market through concessions and subsidies designed to support the spread of tractorisation. No corresponding subsidies or official assistance was given in support of animal draught. In this section we examine the macro-economic context and impact of government policies designed to create such a high tractor density.

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1 The Survey estimates a population of 10,151 4WT against 12,363 known to be registered with the Registrar of Motor Vehicles for the same year.

2 Substantial further imports of tractors took place in 1980 and 1981 so that the surplus capacity problem emerging in 1979 is now likely to have been exacerbated.

3 ie. after appropriate deductions for those committed to non-farm use.

4 5.0 4WT per 1,000 cultivated acres NCAER 1980 Vol I p 4

5 With the exception of veterinary services which are nominally free of charge, but are sparsely distributed and commonly involve a real cost (e.g through the prevision of transport for the veterinary efficer) to the farmer who wishes to use them. The only preposed support for draught animal breeding during this period was made by the Minister of Agriculture and Lands in 1971 (sun newspaper (Colombo) 15.2.71) and involved the import of improved oxen and buffalo from India for breeding purposes. The impact of this effort was restricted to a small number of farms in Polonnoruwa District.

(i) The macro-economic context

Our brief outline in Chapter 1 emphasised the significance attributed to self-sufficiency in staple foods in the formulation of agriculture development policy. In spite of the efforts to expand agricultural production in the last four decades, food imports remained high in the late 1970s, the value of imports was high in relation to Gross Domestic Product, and the rate of expansion of agriculture was being outstripped by that of the construction and services sectors (Table 2.4.1). The construction boom, however, appears to be a short-lived phenomenon linked to the expansion of tourism and to the more open foreign policies introduced after the General Election of 1977. The focus on agricultural development, temporarily masked in the macro-economic statistics by these other events, continues principally in the form of major land settlement in the Dry Zone under the Mahaweli Project. Self-sufficiency in paddy is anticipated by the mid 1980s[1] but the production of other food crops has expanded slowly[2] and self-sufficiency can reasonably be expected only in the distant future.

The resource-base of agricultural development in Sri Lanka is considerably more favourable than elsewhere. Large land and water resources, particularly in the Dry Zone, remain under-exploited, human resources enjoy levels of nutrition and education which compare favourably with other countries in the Region. It is principally in severely deteriorating terms of trade that the drive towards self-sufficiency in basic foodstuffs finds its recent impetus (Table 2.4.2.).

(ii) The impact of mechanisation strategies

There can be little doubt that in the early 1950s mechanisation was viewed by politicians and officials as an innovation which could contribute strongly to increased food production, initially through the clearing and levelling of land to pave the way for new colonisation schemes. After this initial phase it was expected to raise the efficiency of paddy production on the new irrigated settlements by relieving potential labour bottlenecks and by early and better synchronised cultivation. Some dissenting voices, chiefly from technical staff, were raised in this early period, and questioned particularly the compatibility of the 4wt's tillage potential with the small size of individual liyadde, which was determined principally by considerations of water control. In spite of these warning voices and of their apparent inability to identify precisely the technical and institutional measures necessary to permit the services of such a prestigious technology as the 4wt to be translated into practical improvements in the paddy field, politicians and many administrators committed themselves heavily to a programme of subsidised mechanisation, elements of which continued to operate until 1981.[3] The scope of these measures of encouragement is now examined.

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[1] Central Bank of Ceylon Annual Report, for 1980, p.24.

[2] ibid, p.2.

[3] For a detailed review of contemporary accounts of the opinions and attitudes of politicians, administrators and technical personnel towards farm power in the formative stages of mechanisation policy, see Appendix 2.1.

TABLE 2.41: SRI LANKA - RECENT TRENDS IN FOOD PRODUCTION AND IMPORTS

		1978	1979	1980
		(% of value of imports)		
IMPORTS	Food and drink	28	21	18
	Petroleum	16	17	24
	Fertiliser	2	3	4
	Investment goods	23	24	24
	Other	31	35	30
		(Rs. million in respective years)		
VALUE OF IMPORTS[1]		14,687	22,560	33,637
		(% of G.N.P.)		
PRODUCTION	Agriculture	24.1	23.1	22.4
	Paddy only	6.4	6.2	6.5
	Manufacturing	14.7	14.5	13.8
	Construction and services	53.2	54.5	56.2
		(Rs. million in respective years)		
GNP at Constant 1970 prices		17,211	18,389	19,405

[1] These figures reflect both price increases and changes in volume. Between 1979 and 1980, the former rose by 43%, the latter by 14%.

Source: Central Bank of Ceylon, Annual Report, 1980, Colombo.

TABLE 2.42 KEY ECONOMIC INDICATORS - SRI LANKA AND NEIGHBOURING COUNTRIES

Reference	Year	Sri Lanka	Bangladesh	India	Malaysia	Nepal
Agriculture/GDP (%)	1979	25.0	50.7	43.9	24.0	62.3
Manufacturing/GDP (%)	1979	14.4	10.4	15.3	19.8	7.9
Daily per capita protein supply (grams)	1978	41.5	39.3	49.0	56.9	47.7
Daily per capita calorie supply (calorie)	1978	2055	1813	2034	2610	2002
Terms of trade (1970=100)	1979	68.6	-	93.4	104.0	-
Index of Agricultural production (1969=100)	1979	115	112	117	141	112

Source: "Socio-economic data, Sri Lanka", Statistics Department of the Central Bank of Ceylon, Colombo, 1980.

Tractor pools

The early period of mechanisation policy in Sri Lanka is ably documented by Burch (1974). He contrasts the longstanding development strategies for colonisation schemes in the 1940s and early 1950s with the haphazard emergence of a commitment to small-farm tractorisation. In the former case, levels of initial assistance to colonists had gradually been increased to provide a firm basis for development of a 'yeoman' class of financially independent small farmers, relying on animal draught with few technical innovations beyond the planting of improved seed.[1] By contrast, the initial practical interest in small-farm mechanisation arose from the fortuitous gift of some 150 tractors by the departing military authorities in the mid 1940s.[2] Early post-war development proposals had envisaged substantial increases in cultivated acreage, principally in the Dry Zone, as part of the food production drive, and had argued that mechanisation was desirable in principle, under these circumstances.[3] Neither official proposals nor the increasing number of Members of Parliament who, apparently for reasons of personal prestige, requested the allocation of tractors to their constituencies, had analysed in detail the potential for mechanisation. Merely the vague notion that it would make good any labour shortages and improve the timing of cultivation is all that was expressed.

The Department of Agriculture noted an increasing volume of requests from colonists and politicians in the late 1940s for tractor ploughing services.[5] Accordingly, as it acquired tractors, a number of hire stations were opened, initially at Iranamadu, Nikaweratiya, Kalmunai, Wirawila and Nalanda in 1949-51.[6] The charge for ploughing and harrowing was Rs.24/ acre (roughly the value of 2 bushels of paddy) which has been estimated at one-third of the buffalo ploughing cost. For threshing, the tractor charge was estimated at Rs. 0.17 per bushel against Rs.0.77 for buffalo.[7] These tractor charges were, however, adequate to allow a small profit to be made over recurrent costs in the initial years.

From 1952, the main expansion in tractor services came from the Co-operative Agricultural Production and Sales Societies, and their Unions, who bought 241 tractors from Britain in 1952-3.[8] By far the majority of these were allocated to the Dry Zone. Charges were lower than those levied

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[1] Farmer (1957) pp.245-6, found that just over half of the acreage of the Minneriya scheme in the mid-1950s was sown to an improved variety.

[2] Burch (op.cit.) p.8.

[3] Post-war Development Proposals, Govt. Press, Colombo, 1946.

[4] Burch (op.cit.) pp.6-8.

[5] Administration Report of the Department of Agriculture, 1949.

[6] Burch (op.cit.) pp.8-9. All of these were in the Dry Zone, with the exception of Nalanda, which lay in the Intermediate Zone.

[7] Burch (op.cit.) p.9. The basis of calculating the tractor/buffalo differentials is not entirely clear, and it seems almost certain that the gap is overestimated.

[8] The purchase was funded by a 2% loan over 5 years from the Food Production Fund, which had been established by a levy on the estate sector during the war years.

by the Department of Agriculture, at some Rs.20/acre for ploughing and harrowing.[1] Although some reports were made of unused tractor capacity, even at peak periods,[2] utilisation levels were high compared with those currently achieved.[3] In the first year of operation (1953) the co-operatives did not even succeed in recovering running costs, and charges were increased to Rs.30/acre in December, 1953, and to Rs.34/acre one month later. The co-operatives, however, saw the problem as one of surplus tractors which, under conditions of moderately elastic demand, could not be solved by an increase in hire charges. Accordingly, some co-operative tractors were handed over to the Department of Agriculture in mid 1954, and by the end of 1955, a further 86 tractors were disposed of by the co-operatives to the Food Production Department's main tractor station at Anuradhapura.

Those seven co-operative unions which had retained tractors made a small (Rs.15,000) operating surplus in 1955, but were plagued by inadequate supplies of spare parts. The majority of co-operatives and the Food Production Department handed over their tractors to the Department of Agriculture in 1956, which then remained the only official agency involved in tractor hire. The co-operative pools had been an expensive failure: in 1957, a supplementary estimate was submitted to Parliament for Rs.3,867,910 to reimburse the tractor purchase costs and make good the losses incurred by the co-operatives.[4] Their lasting effect, however, lay in the pre-disposition towards mechanisation which their subsidised penetration of the draught market had generated. Data limitations make precise calculations difficult: it appears, however, that the official hire rate was only approximately one-third of the real cost of tractor ploughing in this early period, the remainder being attributable to the subsidy implicit in these losses.[5]

Private tractor ownership gathered momentum during this period. Some 35 tractors were in the hands of large farmers in Dry Zone paddy-growing areas in 1952, but the number of tractors in private hands had risen to 475 by 1956, and private owners were reported to be the most important source of hire for small farmers in five of the six Dry Zone Provinces by 1956. By this time, the village entrepreneur, alongside the large farmer had become a significant force in tractor ownership.[6]

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[1] Calculated from Burch (op.cit.) p.11 for 1953 when Rs.18.69 was recovered for every acre ploughed. Allowing for bad debts, the per-acre charge is assumed to be approximately Rs.20.

[2] Administration Report of Department of Food Production, 1953.

[3] The Co-operatives' tractors ploughed 83 acres each on average in the 8 months, March-October, 1953, and this period would not include the main (maha) ploughing in many parts of the Island (from Burch, op.cit. p.11) against fewer than 30 acres and 20 acres per annum for 4wt and 2wt respectively in the present study.

[4] Burch (op.cit.) pp.13-14. The only other official agency involved in tractor hire during this period was the Food Production Department, which received 112 tractors as a gift from Australia in 1953. It had great difficulty in covering recurrent costs, however. In 1956, for instance, the cost of hire services amounted to Rs.1,054,010, against an income from hiring of only Rs.245,420 (Burch, op.cit., p.15).

[5] Data analysed from Burch (1974, 1980).

[6] Burch, op.cit., quoting Neal, M. E. B. (1957). Private hire charges were slightly above the Department of Agriculture's rates, but the absence of bureaucratic procedures and the early availability of hire services appear to have compensated for this differential.

Tractors and colonisation schemes

The purposeful directing of public tractor hire facilities towards paddy producing areas - among them several colonisation schemes - in the Dry Zone during this early period of mechanisation is noteworthy and deserves some comment. No clear official statement of the precise ways in which tractors would complement (or substitute for) existing productive resources was made, and in the event, the burden was placed on tractors of resolving a number of more general difficulties faced by colonisation policy during this period. For instance, officials quickly recognised that one of the initial difficulties faced by colonists was that of securing adequate labour to complete critical farm operations in a reasonably short time.[1] The problem was postulated as one of labour shortages, not, as seems more plausible, of a holding size larger than that necessary to meet the needs of the allottee and his family.[2] By 1953, officials began to recognise that the large allotments initially granted were not being intensively cultivated. Pressures to reduce the cost of settlement per family also began to appear. The size of new allotments to be granted was therefore reduced from 8 acres (5 acres of paddy and 3 of highland) to 5 acres (3 acres and 2 acres respectively) in 1953 and subsequently to 3 acres of paddy and 1 of highland in 1956.[3]

The essential problem at this early stage of settlement was that labour shortages - always a potential threat at the peak paddy cultivation activities of land preparation and harvesting - were in large degree attributable to colonisation policy itself. The strategy of granting large allotments both to peasants from the Wet Zone but also to those living in the vicinity of colonisation schemes[4] reduced the potential supply of casual labour upon which the timely completion of peak activities depended and continues to depend in spite of widespread tractorisation.[5]

Further, irrigation water consumption was high in this period, and the potential of tractors for reducing it had not been thoroughly analysed. Whilst some of the first tractors to be privately owned had been put to work on the large farms of the Eastern Province on which paddy was grown under a combination of rainfed and irrigated conditions, and some success in improving the timing of cultivation has been attributed to tractors there (Carr, 1975, p.245ff), the problem of using water more efficiently on major irrigation schemes was altogether more complex, and merited more serious attention than was offered by the simple faith in tractorisation as a means of advancing and synchronising the cultivation season. In the event, most tractors on colonisation schemes substituted directly for buffalo - ploughing with a crude implement, the 9-tine tiller,[6] under mud conditions. No attention

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[1] i.e. to achieve a sufficiently early and well-synchronised cultivation to correspond with the bimodal rainfall distribution.

[2] See Appendix 2.1.

[3] Farmer, 1957, pp. 275-294.

[4] Farmer (op.cit.) p.211.

[5] It is crucially significiant in this context to note results from the present survey which indicate that tractorisation has led to a reduction not of hired but of family labour inputs (Chapter 4). Whether the same labour displacement pattern held in the early years of tractorisation cannot be known, but the possibility should at least have been considered by administrators, and surveys conducted to establish the pattern of tractor/labour substitution.

[6] In the private sector, overwhelmingly the most popular implement.

appears to have been paid to the role of the irrigation bureaucracy in timing the initial issue of irrigation water, and in deciding the proportion and duration of total issues to be made for pre-wetting during land preparation. The possibility of increasing the collaboration among farmers and between farmers and the irrigation bureaucracy, was not considered until the late 1970s.[1] The fact that there would be no incentive for an individual farmer to till early - with or without a tractor - unless virtually the entire population of an irrigation scheme could be persuaded to do the same,[2] was not recognised. The emphasis throughout this period was on the provision of advanced technology to the farmer, not on the establishment or modification of institutions to ensure that such technology could be used to its full potential.

The expansion of private tractor ownership

After this initial unsuccessful experiment with tractor pools, some hiring operations through the Department of Agriculture's tractor stations continued, but private ownership, assisted by numerous subsidies and concessions, burgeoned. Of the 855 tractors available for small farm use at the end of 1956, 475 were in private hands.[3] By 1962, the total number of tractors registered in the Island had reached 2,080, and by 1976 was 12,873.[4] Official policy by the mid 1960s had switched firmly in favour of private ownership.[5]

Government assistance for private tractor ownership included a preferential rate of import duty, which remained at 1% for tractors, implements and their spare parts up to 1967, when it was raised to 10% on tractors and implements and 5% on parts. Occasional concessions such as the waiving by the Minister of Finance[6] of a backlog of duties on tractors and diesel fuel in 1957 were also made. Throughout the 1950s and 1960s preferential allocations of foreign exchange were made for tractor imports when the import of other capital goods was severely limited.[7] Only in 1968 did the foreign exchange allocated for the purchase of tractors and their implements become subject to a 45% levy under the foreign Exchange Entitlement Certificate Scheme (FEECS). This was raised to 55% in 1972 on 4wt, but 2wt had been given preferential treatment by the imposition of a 25% import duty instead of the FEECS levy in 1970.[8] In spite of the partial removal of

[1] With e.g. the current ARTI/USAID Water Management Study at Gal Oya.

[2] See above Chapter 1.1.

[3] Neal, 1957.

[4] Registrar of Motor Vehicles, Colombo, personal communication.

[5] Agriculture Development Proposals 1966-70, Government Press, Colombo.

[6] Ceylon Daily News, 7.3.57.

[7] See Plumbe and Byrne, 1981. Also Carr, 1975, p.17, reports that 28% of the total foreign exchange component of the 1966-70 Agriculture Development Proposals was set aside for the import of tractors and spares. In the same proposals it was stressed that these were particularly to be allocated to paddy production in the Dry Zone (Carr, ibid, pp.72-5).

[8] Carr (1975, p.78) claims however that part of this incentive towards 2wt ownership was lost by a disproportionate increase in distributors' margins which kept prices high.

concessions on tractors vis-a-vis other imported capital items which these increases imply, it has been argued[1] that the real value of foreign exchange in the 1960s and early 1970s was at least 100% above the official rate, so that imported draught technologies continued to be heavily subsidised relative to the indigenous in spite of these increased levies.

Additional subsidies to the use of tractors included the operation of the Agriculture Department's tractor pools at below cost hire charges in the late 1950s and 1960s. Whilst the significance of these relative to private ownership steadily diminished, their subsidised charges continued as an expression of official commitment to mechanisation, and helped to popularise tractor ploughing. Their losses, reported to be Rs.1.5m per annum in the 1960s,[2] were met from the public purse.

Hidden subsidies were also provided by a number of medium term credit schemes for the purchase of tractors from the mid 1960s. Their features include concessionary rates of interest and the lowering of criteria for acceptance of borrowers below those commercially applicable. The schemes include one applied to major irrigation schemes for the purchase of 2wt in the early 1970s,[3] another towards youth settlement schemes in the southern Dry Zone,[4] and others linked to the rehabilitation of existing major irrigation schemes.[5] In all cases, the rates of default on credit repayment are substantial, and the ability of the lending agency to repossess the tractor is severely limited, so that the purchase cost of these tractors is, in effect, heavily subsidised.[6]

With the abolition of the FEECS scheme in 1977 and the adoption of a floating exchange rate, much of the hidden subsidy on tractors was removed. By that year, however, very substantial numbers of tractors - some 13,300 4wt and 6,150 2wt - had been registered.[8] Tractor operations, particularly in short haul transport,[9] at a time of severe restriction on lorry imports, were highly profitable,[10] and the rapid expansion of tractor imports under liberal foreign trade policies following the 1977 General Election is largely an expression of pent up demand and the expectation of substantial profit from hiring operations developed during the early 1970s.

Only two main sources of subsidsy on the ownership and use of tractors remained after 1977. First, the Lump Sum Depreciation Allowance, whereby the full value of all capital items, including tractors, which can be used to increase agricultural production, is deductable for tax purposes from gross income in the year of purchase, was continued up to March, 1981.

[1] International Labour Office, (1971).
[2] Burch (1980) p.371.
[3] Carr, (1975) pp.297-8.
[4] Wirasinha, (1974).
[5] World Bank (1976).
[6] Burch (1980) pp.350-355.
[7] Carr (1975).
[8] Registrar of Motor Vehicles, Colombo, personal communication.
[9] Plumbe and Byrne (1981).
[10] Harriss (1977) p.174, for instance, estimated that in the early 1970s, profits were high enough to permit the capital cost of a 4wt to be recovered in 2 years, and of a 2wt in 18 months.

That the benefits of this allowance played a strong role in promoting tractor purchase is suggested by the frequent references to it contained in tractor advertisements in early 1980, once its impending discontinuation had become common knowledge. Second, the cost of diesel - by which the vast majority of tractors is fuelled - was heavily subsidised until late 1980, relative to both the internal price of petrol and to the cost of importing diesel.[1]

(iii) The changing context of tractorisation

Two features of the agricultural and institutional context of tractorisation of particular relevance to this study have changed radically from the early 1950s when tractors were first expected - albeit without sufficiently careful planning - to make a significant impact on agricultural production. Both are likely to reduce the economic efficiency and socio-political acceptability of 4wt use from the levels anticipated in the early years of mechanisation, and so, although already briefly alluded to, merit particular emphasis.

First, the attempts to spread the opportunities for access to tractor services, and to minimise their contribution to the polarisation of incomes and wealth, through co-operative and government ownership with subsidised hire services, have been discarded in favour of widespread private ownership. Perhaps the only lasting impact of these schemes is that they introduced to a much wider body of farmers than might otherwise have been the case the benefits of reduced toil and lower labour requirements that are observed to accompany tractorised ploughing - a combination which may have contributed strongly to the adherence to tractor ploughing even during subsequent hire-charge increases.

Second, the new allocations of paddy land in many parts of the Dry Zone for which tractorisation was initially intended - i.e. the colonisation schemes - were progressively reduced from the 5-9 acres per family of the late 1940s to 3 acres in the mid-1950s and 2 acres under current schemes. This has served to widen the gap between the performance potential of a 4wt and the scope for its use on the owner's land, thus increasing the reliance on custom work in a period during which the plots of potential customers were also becoming smaller, with increased time requirements for negotiating the additional contracts for a given acreage ploughed, and for travelling between jobs.

Of some interest are the relatively recent efforts to promote tractor ownership in precisely these areas. For the Tank Irrigation Modernisation Project, for instance, an input of 60 4wt and 180 2wt was envisaged.[2] These were to be provided as part of an aid programme and sold to colonists on credit at concessionary rates of interest. In spite of the extensive safeguards designed to allow only bona fide cultivators to purchase tractors under this agreement (Parker, 1978), many tractors provided under the Project fell into the hands of those with substantial business interests. Of the eight 4wt sold under the TIMP in our sample three went to persons in this category. A further one was sold to a permanent civil servant.

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[1] The precise size of the subsidy is difficult to calculate, but it has been at least 50% of the retail price since 1973. See Appendix 6.1.

[2] World Bank (1976).

Similar tractor inputs provided under foreign aid were envisaged for many parts of the major settlement efforts under the Mahaweli diversion,[1] and the provision of some 500 4wt and 1,000 2wt under subsidised credit to small farmers was envisaged as part of a recent foreign-aided rural credit programme (FAO, 1979).

(iv) A summary of the policy context

The main trends in the development of tractorisation may thus be summarised as follows:-

- an expectation in the early 1950s that 4wt could compensate for labour shortages and make more efficient use of water, both in rainfed areas and in relatively large paddy allotments then being granted under land settlement projects.

- the support by a variety of policy measures of both the private and (especially during 1952-56) institutional ownership of 4wt.

- the provision of tractor hire services at subsidised rates, contributing to their popularity, particularly in 1952-56, and to a lesser extent up to the mid-1960s.

- a progressive reduction in the size of holdings newly allotted under land settlement, making it increasingly difficult for those engaged solely in cultivation to use a tractor economically in their own holdings and to obtain an adequate volume of contract work in agriculture.

- the demise of institutional ownership and operation of tractors, through corruption and inefficiency, in the 1960s and early 1970s; followed, with the post-1977 liberal trade policies, by an influx of new tractors purchased largely by those pursuing multiple economic activities, of which farming was not necessarily the most significant.

- a large number of aid agreements attempting, in spite of reductions in average holding size and the consequent difficulty of finding adequate work to make tractor operations profitable, to channel large numbers of 4wt and 2wt into the hands of small cultivators in settlement areas, commonly with concessionary purchase schemes.

- this, combined with the de-monopolisation of tractor imports after 1977 and the subsequent rapid increase in commercial activity, leading to a massive influx of tractors and an improvement in the age-structure of the tractor fleet.

The present situation therefore arises from a rapid expansion of tractor imports[2] since 1977, many of them, with the support of foreign aid agencies, being directed towards smallholder irrigated settlements where some of the early rationale for their use has disappeared. Procedures intended to ensure that (especially) 4wt are purchased and used by small cultivators appear to have been unenforceable and have only partly succeeded in

[1] e.g. 300 4wt and 1,200 2wt were initially envisaged as necessary for the 70,000 acres scheduled for development under System H.

[2] Current data for 1981 in conjunction with Figure 2.3 indicate a doubling of the 2wt population since 1977 and a 50% increase in the 4wt population.

counteracting the evident economic pressures towards purchase of new tractors by those with substantial and diverse non-farming interests. Recent evidence suggests that the rate of sale of new tractors is slowing down. Of the 60 4wt and 180 2wt designated for the TIMP, for instance, only 67% and 30% respectively were sold. Very few of the 100 4wt made available to settlers under the first phase of Mahaweli System H have been sold (McKinlay, personal communication). Unconfirmed reports also suggest that the State Trading (Tractor) Corporation is having difficulty in disposing of stocks of 4wt imported in early 1981.

This trend of declining sales reflects, at the macro level, both a fulfilment of pent-up demand following the 1977 trade liberalisation, and an impending saturation of the market for tractors in transport and agricultural uses. Further, it reflects the fact, at the micro level, that acreage reductions, escalating costs of purchase and operation and a continuing large volume of animal draught in many areas make the ownership and use of tractors economically difficult for small farmers. Sales therefore inevitably diminish once the larger farmers and those with diverse business interests have been satisfied.

2.5: Draught Power at the Study Locations

Given the national context of policies designed to support tractorisation, and the increasing share of small-farm draught power supplies provided by tractors, it is now appropriate to turn to the current size and composition of the draught power stocks as a whole at the study locations.

2.5.1: Inter-location comparisons

A summary of the distribution of draught power among the locations is presented in Table 2.5.1.[1] Substantial differences exist between locations in the densities of individual power types. Four-wheel tractors and buffalo are strongly represented at Padaviya, and 2-wheel tractors at Uda Walawe and Minneriya.[2] An interesting comparison can be drawn between the sample densities (Table 2.5.1) and the Dry Zone and national densities discussed above (Table 2.3.1).

Allowing for the fact that an availability factor has been applied in Table 2.3.1 to produce a density of 'effective' power units, but only the crude densities are presented in Table 2.5.1, the sample and Dry Zone data bear some similarity. The Dry Zone 4wt density, for example, falls squarely within the range of densities observed among the locations (Padaviya lying at an extreme 'high' density). The same would apply to buffalo densities if an availability factor were applied to the sample data. For 2wt, however, the sample densities are substantially higher than that for the Dry Zone overall.

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[1] For a much more detailed discussion, see the Part 1 Report, Chapter 3.1.

[2] Minneriya is adjacent to Kaudulla. Although it was not selected as a study location, data provided by courtesy of agricultural officers on the scheme provide some interesting comparisons, Minneriya having been rehabilitated some years earlier than the other schemes, with much larger holding sizes (5 acres of paddy and 3 acres of highland, against, in the main, 3 acres of paddy and 1 of highland).

TABLE 2.5.1 : FARM POWER DENSITIES PER 1,000 ACRES OF PADDY[1] BY TYPE AND STUDY LOCATION

Location	Power Type:	Density per 1,000 acres of Paddy 4wt (Nos.)	2wt (Nos.)	Buffalo (Pairs)
UDA WALAWE		3.5	20.7	182.1
KAUDULLA[2]		3.0	8.0	171.9
PADAVIYA		14.1	11.2	334.0
MINNERIYA		7.9	30.0	109.5

Notes: 1. Paddy acreages are taken from official records for maha 1978-9 at Uda Walawe and Padaviya, and from Blocking Out Plans (BOP) at Kaudulla and Minneriya. The Part 1 Report (Appendix II) discusses reasons for preferring official records over BOP.
2. Stage I only is taken at Kaudulla, in view of the recent completion of parts of Stage II, and their atypically low farm power stocks.

SOURCE: PART 1 REPORT.

Disparities between the study locations and overall figures for the Zone can be accounted for largely in terms of local historical circumstances. These include the influence of the Tank Irrigation Modernisation Project in providing credit for 4wt and 2wt at Padaviya, that of similar schemes for 2wt at Uda Walawe, the more abundant availability of buffalo grazing land at Padaviya than elsewhere, and so on.[1] Some features of the distribution appear, however, to be attributable to general trends: the comparatively strong role of tractors at Minneriya, for instance, corresponds with its longer period of establishment and larger holding sizes, and, therefore, greater prospects for capital accumulation.

2.5.2: Intra-locational variations in density

A variation in the overall density or composition of farm power among locations is not the only factor which might influence farmers' access opportunities to and use-patterns of farm power. It might similarly be hypothesised that on such large irrigation schemes as the ones we are considering[2] any disparity in farm power density between top and tail end will influence access opportunities and use-levels.

In the Part 1 Report is presented a location-wise summary of the addresses at which power units are normally kept. This shows a trend of declining density of both 4wt and 2wt with increasing distance from the tank bund at each location. The same trend is not observed for buffalo ownership. The declining trend in the case of tractors appears to be largely a reflection of the greater wealth for purchase and hire of tractors at the upper ends of irrigation schemes (see Chapter 5 below). Significantly, for Minneriya, a scheme of relatively large holding sizes and of equitable water availability (and therefore wealth), the spread of ownership of all power types is comparatively even over the scheme as a whole.[3]

[1] For a more detailed discussion see Part 1 Report, Chapter 3.

[2] Padaviya is approximately 8 miles from tank bund to bottom end; Kaudulla 9 miles and Uda Walawe 18 miles.

[3] Part 1 Report, Chapter 3.

2.5.3: Ownership concentration of farm power

It is possible to hypothesise that a high concentration of farm power in the hands of a few individuals will generate market structures conducive to oligopolistic behaviour in power-hiring markets. Such potential distortions of the hire-markets are of strong interest to this study, and, accordingly, farm power population data were examined in the Part 1 Report both by locations and by sub-areas within locations, for any high concentrations of ownership.

At all locations the norm was for an individual owner to possess only one tractor, be it 4wt or 2wt, with only rare exceptions. With buffalo however, significant variations in the pattern across but not within locations were observed. The mean densities were:

Uda Walawe	40 adult buffalo per owner
Padivya	13 adult buffalo per owner
Kaudulla	3 adult buffalo per owner
Minneriya	4 adult buffalo per owner.

These differences give rise to two hypotheses which will be tested in subsequent chapters, namely:

1. that the higher ownership concentration of buffalo at Uda Walawe and Padaviya are conducive to oligopolistic behaviour in the hire markets;

and

2. that the large herds at Uda Walawe and Padaviya reflect a highly concentrated ownership of animal draught power which owners cannot easily split into the small units of use-time required on a day-to-day basis by potential hirers for their small paddy farms. This, in turn, may lead to low use-intensity of the herds, the adoption of low-efficiency animal cultivation techniques, or both.

2.6: Human Resources at the Study Locations

2.6.1: Farm family labour

Conventional economic analysis postulates an allocation of family labour between productive activities and leisure such that the ratios of perceived cost to perceived benefit are equated at the margin. Within productive activities, the same principle is applied among alternative directly productive enterprises which compete for labour time, between those enterprises which are directly and those indirectly productive, and within the indirectly productive.

Labour allocations among activities will vary over time (particularly during the agricultural season), since shifts in the perceived marginal cost:benefit ratios will occur as, for instance, the timing of a given agricultural operation becomes critical. At such times the perceived marginal benefit of applying additional labour within a given time period may be so high as to cause farmers to supplement family labour resources with hired labour.

[1]Becker's (1965) Z-goods are an example.

A detailed discussion of the interaction between timing of operations, mechanisation, and hired and family labour use is reserved for Chapter 4. In the present context, however, it is useful to outline the availability of family labour resources, comparing it with the distribution of the farm power stock and with comparable data on farm family size obtained in other studies.[1]

Table 2.6.1 summarises the overall size of the family workforce and the number of adult equivalents available for work in agriculture. In estimating the family workforce, weights of 1.0 are applied to males and females in the age range of 15-65 years, and 0.5 to those over 65 or between 5 and 14 years. A similar convention is used in estimating the availability of the family labour force for farm work, together with the head of family's estimate of each member's availability, allocated into class intervals of 0%, 25%, 50%, 75% and 100%.

This is recognised as a crude method by comparison with known complex variations in the work-efficiency and working day length patterns across male, female and juvenile labour in peasant farming.[2] It does, however, provide a broad indication of variation in family sizes, and the overall workforce sizes given in Table 2.6.1 correspond closely with those reported in numerous other studies of the Dry Zone (e.g. ARTI, 1979a and 1979b).

Whilst the proportion of the total workforce available for farming is higher in the non-owner sample, the difference is not significant nor is there any significant difference in the size of workforce. The direction of these differences corresponds with what might be anticipated: owners are likely to have a wider variety of non-farm activities than non-owners; they might also be better placed to enjoy relatively more leisure. Their participation in agricultural activities might therefore be expected to be low. This pattern is reinforced by analysis of the participation rates according to power type owned: 4wt owners have lower availability (in both[3] absolute and relative terms) for farm work than other owners or non-owners. Of particular interest in the owner sample is the significantly lower overall availability at Uda Walawe than at the other locations. This corresponds with the stronger role played by the local commercial centre (Embilipitiya) in drawing labour and tractor use-time out of agriculture, a feature of Uda Walawe already touched upon[4] and one to which we return below (Chapter 5).

For non-owners, interesting (though non-significant) differences emerge between locations, the availability for farm work being high (in absolute terms) for Kaudulla, and low (in absolute and relative terms) for Padaviya. Within locations, the availability for farm work might be expected to vary inversely to the availability of farm power. Mechanised power, as we have seen[5] is weighted in its spatial distribution towards the upper reaches of command areas in all locations;[6] a heavier reliance on human resources at the tail ends might therefore be anticipated. At each location, the

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[1] The summary presented here is derived from the more detailed data presented in Appendix 2.2.

[2] See Farrington, (1975).

[3] The difference between 4wt owners and non-owners is significant but other differences are not.

[4] Part 1 Report, Chapter 3.2.

[5] Part 1 Report, Cahpter 3.1.

[6] The stratification of non-owner samples between top and tail ends of irrigation command areas is discussed briefly in Chapter 1.4 and in detail in Appendix 1.

TABLE 2.6.1: MEAN SIZE OF FAMILY WORKFORCE AND AVAILABILITY FOR FARM WORK

	UDA WALAWE Adult Equivalents			KAUDULLA Adult Equivalents			PADAVIYA Adult Equivalents			ALL LOCATIONS Adult Equivalents		
	Size of Work-force	Avail-ability	% Avail-ability	Size of Work-force	Avail-ability	% Avail-ability	Size of Work-force	Avail-ability	% Avail-ability	Size of Work-force	Avail-ability	% Avail-ability
OWNER SAMPLE												
4wt Owners	4.83 (0.54) (20)	1.38 (0.28)	28.6	4.12 (0.35) (13)	1.37 (0.25)	33.3	4.44 (0.35) (33)	1.81 (0.23)	40.5	4.49 (0.31) (66)	1.58 (0.18)	35.2
2wt Owners	4.35 (0.45) (26)	1.43 (0.20)	32.9	5.85 (0.61) (20)	2.79 (0.26)	47.7	4.80 (0.45) (23)	2.07 (0.28)	43.1	4.93 (0.36) (69)	2.04 (0.22)	41.4
Buffalo Owners	5.61 (0.56) (19)	2.24 (0.22)	39.9	5.90 (0.29) (24)	2.93 (0.18)	49.7	6.03 (0.44) (20)	3.38 (0.70)	56.1	5.85 (0.24) (63)	2.86 (0.24)	48.9
All Owners	4.87 (0.31 (65)	1.65 (0.14)	33.9	5.48 (0.32) (57)	2.53 (0.15)	46.1	4.97 (0.29) (76)	2.30 (0.18)	46.3	5.08 (0.16) (198)	2.15 (0.11)	42.3
NON-OWNER SAMPLE	4.63 (0.24) (76)	2.38 (0.13)	51.4	5.06 (0.25) (73)	2.56 (0.16)	50.6	5.23 (0.25) (80)	2.17 (0.13)	41.5	4.98 (0.14) (229)	2.37 (0.08)	47.6

Notes: In each case, standard errors and numbers of observations are given in parentheses below the means.
In Table 2.6.1 and all subsequent tables in which owners are classified by power type owned, the convention adopted in cases where two different types are owned by the same sample member was to allocate him into the category appropriate to the power type having the highest horsepower, An owner having both buffalo and 2wt, for instance, is treated as a 2wt owner. This convention was necessary only in a small proportion of cases.

proportion of family labour available for farm work at the tail ends is in fact higher than the location average, but not significantly so, and no clear trend emerges of rising availability with increasing distance from the irrigation headworks. This evidence should therefore be treated with some caution: whilst a higher proportion of non-owner family members may work on tail end than on top end farms, any difference in labour requirements arising from lower use of mechanisation at the tail ends could equally well be met from longer working hours per available worker there.[1]

2.6.2: Patterns of labour hiring

The pressure exerted by human populations on land resources varies enormously by agro-climatic zone. Population densities exceed 1,000 persons per square mile on average in the Wet Zone, but are only 233/sq. mile in the Dry Zone.[2] Given also the predominance of smallholder agriculture in overall economic activity and the highly seasonal time-profile of paddy production in the Dry Zone, especially where a degree of synchronisation is imposed through irrigation schedules, it is inevitable that the resident Dry Zone population will be fully occupied in their own agricultural activities all at approximately the same time, with little supply of labour onto the hire market at times when it is most urgently required. Two recent studies[3] have focussed on a widespread alternative practice, namely that of hiring seasonally migrant labour from the Wet Zone. Crooks and Ranbanda (1981) estimate, for instance, that in the Polonnaruwa paddy complex (where Kaudulla is situated) the resident labour force is capable of providing only some 60% of the necessary labour for land preparation and 20% of the labour for harvesting, threshing and winnowing.[4]

Whilst they were unable to provide data on the proportion of hired labour that was migrant, they emphasised the significance of earnings from migrant work in the annual cash incomes of Wet Zone families (29%-58% according to location), thus focusing on a transfer of earnings both geographically and from relatively rich to relatively poor households, an income-distribution mechanism of some importance in the present agricultural economy, which may be adversely affected by any trend towards increased mechanisation.

The role of seasonally migrant labour at the three study locations is examined in Appendix 4.3, and is found to be significant principally at Kaudulla, which is located within the Polonnaruwa paddy complex.

The available evidence suggests a strong positive correlation between the volume of migration and the proximity of Dry Zone 'recipient' location

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[1] It would be irrational to expect tail enders to meet any higher labour requirements by hiring in more labour, in view of their generally poorer financial status. The fact that they hire in less labour per acre is borne out by expenditure data presented in Appendix 5, and labour data in Chapter 4.

[2] Based on Census and Statistics Department Projects for 1981 at 2.1% average annual growth rate.

[3] Crooks and Ranbanda, (1981); Perera and Gunwardena (1980).

[4] Whilst there are a number of debatable assumptions in their methodology, which may have led to an over-estimate of the labour requirement, the actual requirement is still likely to remain in excess of what the resident workforce can supply, and comparative analysis suggests that this area is particularly short of labour at peak periods.

to Wet Zone villages from which migration originates. The likelihood of obtaining employment also appears to be a significant factor: Kaudulla is located among some 60,000 acres of contiguous paddy farms in Polonnaruwa. It might, therefore, benefit from greater migration than a location at similar distance from the Wet Zone offering similar employment opportunities, which is not surrounded by intensive farming.

Migration seems to offer few potential disadvantages: its productive and distributional effects are both strongly positive. The opportunity facing administrators is that of increasing its flow to areas which benefit only peripherally from it, both as a complement to and, in some degree, as a substitute for mechanisation.

CHAPTER 3: KEY PERFORMANCE INDICATORS OF FARMS WITH VARYING DEGREES OF MECHANISATION

It is worth emphasising that there is no unique relation between the costs of mechanised and those of traditional technologies. For instance, the ratio may vary spatially according to local resource endowments and temporally with fluctuations in world markets for fossil fuels and industrial commodities. Furthermore, official support measures for one or the other technology will cause farm gate price ratios to vary from border prices. In Sri Lanka, the real economic cost to the economy of tilling and threshing by tractor is currently substantially higher than by buffalo (Appendix 9), though the evidence indicates that this gap was narrower in the early period of mechanisation. To offset these higher costs, benefits were sought in terms of increased agricultural production. To what extent such benefits have emerged is examined in this chapter.

Samples of farms analysed in studies of farm power are commonly stratified into 'mechanised' and 'non-mechanised'. In the present context, however, such a broad classification has little meaning. Some farms are mechanised in one or more operations, others not at all. Even those farmers who own a power unit use it only for selected operations (cf Table 2.2.1), and may hire in other types as required.[1]

The definition of degrees of mechanisation therefore needs to be flexible enough to allow appropriate levels of detail of farmers' power-use patterns to be reflected in the analysis of their performance. The strategy adopted was to stratify the sample ex ante into owners and non-owners of farm power, the former being sub-classified by type(s) owned, and to classify the non-owners ex post into groups according to the type of power used for specific operations.

Even the term 'non-owner' is not a completely accurate description - with such a long term field survey (August, 1979-October, 1980) some members of the samples changed their status by buying or selling power within the survey period. Fortunately, very few[2] cases of this occurred in either sample during the 14 month period. Before proceeding to analyse the impact of tractorisation, it is first necessary to describe the patterns of farm power use among owners and non-owners, taking into account both the spatial distribution of the farm power stock and the varying quality of access to productive resources (especially irrigation water) within major irrigation schemes.

3.1: Farm Power Use by Ownership Status

In Chapter 2 above, we discussed the differences in spatial distribution of farm power by type, by location and by sub-area within location. We concluded that, first, there was a systematic decline in the density of

[1] For instance, all buffalo owners at Kaudulla and Uda Walawe and 36% of those at Padaviya hired 4wt for threshing but not for any other field operation.

[2] At Kaudulla, however, the ownership of small herds of buffalo was widespread, and a small proportion of those selected as 'non-owners' were found during the course of the survey to own buffalo.

4wt and 2wt (but not of draught animals) within locations from top to bottom of the command area, corresponding with the decreasing reliability of irrigation for paddy cropping, and with diminishing levels of income and wealth, but, second, the variation in farm power densities among locations appeared to arise from a combination of historical circumstances and differing patterns of income and wealth.

Presented in Table 3.1.1 are the proportions of non-owners'[1] paddy acreage ploughed and threshed by hired tractors. Comparisons across locations indicate that proportions vary directly with the observed differences in tractor:buffalo ratios. (Table 2.5.1) Thus, at Kaudulla, which has the lowest ratio of tractor to buffalo power, the proportions of land ploughed and threshed by tractor are lower than elsewhere.

Comparisons within locations indicate that the proportion of land ploughed and threshed by tractor declines with increasing distance from the headworks, the only exception being at Kaudulla, where little change in the proportions is observed. This is attributable to the widespread preference for ploughing by buffalo in all parts of the command area.[2] The acreages ploughed by tractor within Kaudulla are so small as to prevent reliable comparisons among sub-areas. The general result of a declining role of tractors with increasing distance from the headworks corresponds with the biased spatial distribution of tractors already noted, and illustrates the imbalance in access opportunities to mechanised technologies within major irrigation schemes. Part of the imbalance may be attributable to the more severe incidence of poverty among tail-enders, forcing them to rely on technologies which involve lower cash outlay but correspondingly higher inputs of non-cash items such as family labour.[3] As we shall argue later, however, much of the reduced access opportunity is likely to stem from the imbalance in spatial distributions of tractors.

TABLE 3.1.1: PROPORTIONS OF NON-OWNERS' PADDY ACREAGE[1] PLOUGHED AND THRESHED BY HIRED TRACTORS[2]

		UDA WALAWE %	KAUDULLA %	PADAVIYA %	ALL LOCATIONS %
Top[3]	Sample 1	79.3	37.9	57.5	59.3
	Sample 2	70.7	44.0	75.2	65.1
Tail	Sample 3	56.7	43.9	27.4	38.2
	Sample 4	61.5	-	46.4	52.5

Notes: 1. Maha and yala acreages are combined.
2. 2wt and 4wt combined, although threshing was restricted to 4wt.
3. Two samples at each location represent good access to inputs, especially irrigation water, at the top ends of command areas, with two contrasting samples from the tail ends. Kaudulla tail end comprises one sample from the command area, and one from a village below the scheme boundary which relies partly on drainage water from the scheme for irrigation. This was excluded from the present analysis of tractor distribution and use patterns within irrigation schemes. See also Appendix 1.

[1] The same analysis cannot be applied to the owner samples, since the sampling scheme was structured to give roughly equal representation to owners of the three power types at each location, so that the proportions of different power types contained in these samples do not correspond with the proportions in the populations from which they were drawn.

[2] If only threshing is considered, the proportions performed by tractor in Kaudulla decline with increasing distance from the headworks.

[3] Higher proportions of family labour could be used either in direct land tilling or in conjunction with animal draught.

3.2: Farm Power Use by Type of Operation

Data obtained on the agricultural activities of the non-owner sample provide the basis for estimating the work-rates of different power types on mechanised operations. Acreages were measured directly for this sample, and the data on farm power inputs were collected two or three times per week, so that the accuracy of power work-rates provided by non-owners is expected to be high.

Table 3.2.1 indicates that there are no significant differences in the per acre use levels for individual operations between maha season only and combined maha/yala data. In order to exclude the possible emergence of bias through incorporation of operations which were partly performed by one power type and partly by another within the same plot, only those observations were selected in which the complete operation was performed by the power type in question.[1] Thus, tilling by 4wt includes only those observations in which both first and second ploughings were performed exclusively by 4wt. Four separate classifications of tilling by animal power are presented. These correspond with different tillage methods and include, first, 'mudding' or 'trampling'[2] without the use of implements (common at Uda Walawe, less so at Padaviya and absent at Kaudulla); second, ploughing which is used throughout Kaudulla and by some farmers at Padaviya; third, a combination of ploughing and mudding (both by animal) on the same plot; fourth, ploughing by 4wt, followed by mudding by animals. These last two practices are common only at one study location, Padaviya. None of the tilling operations includes power time spent on levelling.

One consequence of this rigorous classification is that the number of observations of operations performed by each power type does not fully represent the popularity of the power type in the operation in question. The broad ranking of popularity is, no doubt, correct - buffalo are heavily employed in levelling, for instance, whereas 4wt are not - but the roles of those power types which are frequently used in conjunction with some other in a particular operation are likely to be underestimated. For instance, 4wt are frequently used in first ploughing, followed by 2wt or buffalo for second ploughing, and so the 18 cases observed of full tilling by 4wt may underestimate its significance in this operation.

As far as the power mix for individual operations is concerned, the data (Table 3.2.1) do, however, allow us to draw the following conclusions:

(i) animal draught appears to be more commonly used than tractor power for tilling and levelling, but not for threshing, where 4wt predominate;

(ii) 4wt are more commonly found in winnowing, but, as we shall see in Chapter 4, the use of human labour alone is more common than any form of mechanical power in this operation, although relatively rare in the other three.

The work rates presented in Table 3.2.1 are broadly consistent with estimates derived from the most conveniently available cross-check, namely the responses by power owners regarding the daily use of their power

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[1] Apart from the case of combined tillage by 4wt and buffalo noted in Table 3.2.1.

[2] See Glossary.

TABLE 3.2.1: NON-OWNER SAMPLE: PER ACRE TIME INPUT OF FARM POWER FOR THOSE OPERATIONS SUBJECT TO SOME MECHANISATION[1]

	ALL LOCATIONS Maha Only			ALL LOCATIONS Maha and Yala Combined		
	Power hrs/acre Mean	S.E.	No.of Cases	Power hrs/acre Mean	S.E.	No.of Cases
TILLING						
by 4wt	5.3	0.7	18	5.3	0.7	18
by 2wt	13.9	1.0	39	14.0	1.3	59
by animal[2]	109.1	14.9	35	97.2	10.0	55
by animal	67.9	5.9	101	67.7	4.5	141
by animal	122.0	23.4	20	122.0	23.4	20
by animal + 4wt[3]	72.8	15.4	17	72.8	15.4	17
LEVELLING						
by 4wt	2.1	0.0	1	2.1	0.0	1
by 2wt	4.9	0.3	24	4.7	0.3	43
by animal	18.6	1.3	159	18.1	1.0	197
THRESHING[4]						
by 4wt	3.1	0.3	179	2.8	0.2	237
by animal	35.8	2.9	79	33.7	3.1	100
WINNOWING						
by 4wt	1.7	0.4	8	1.7	0.4	8
by 2wt	3.9	0.4	66	3.1	0.2	102
by machine[5]	2.7	0.8	7	2.7	0.8	7

Notes:
1. The farm power sub-categories for each operation refer to those plots on which only the type of power in question was used. Several cases were encountered in which different types of power were used by one farmer on the same operation; those were excluded from the analysis. This restriction does not apply to the case of human labour, which complemented other types of power in all operations. The 'by hand' category refers to those cases where human labour alone was employed.
2. Three categories of animal powered cultivation are defined. The first refers to the practice of trampling or 'mudding' the pre-wetted soil without implements; the second, to the use of animal drawn ploughs in tilling, and the third to a combination of the first two.
3. A common practice at Padaviya comprised an initial ploughing by 4wt, followed by animal 'mudding'.
4. Threshing by human power involved rubbing the heads of grain on the ground under the human foot.
5. A hand or foot operated winnowing fan.

source by operation and acreage.[1] The data obtained by this cross-check are presented in Appendix 3.3. To summarise, owners'[2] estimates indicate that an average 4wt will take from 4.25 to 7.17 hours for full tilling of an acre, a 2wt 12.11 to 17.65 hours and a pair of buffalo, 40.21 to 80.38 hours. For threshing, owners estimate that a 4wt will take between 1.45 and 2.12 hours, and a pair of buffalo between 30.08 and 41.83 hours per acre.

Thus, the mean work rate estimates across locations by those hiring in farm power (i.e. the non-owner sample) fall squarely within the range of performances given by location by those hiring it out (i.e. the owner sample). There are only two exceptions: first, non-owners' estimates of the time required by 4wt for threshing (2.8 hrs./acre - Table 3.2.1) lies above the range of time requirements estimated by owners (1.45-2.12 hrs./acre). Second, the estimation of work rates for buffalo in tilling is complicated by inter-locational variations in the tillage practices. Some broad consistencies are observable: for instance, the time taken to till an acre by ploughing[3] is lower in both non-owners' (67.7 hrs./acre) and owners' (40.21 hrs./acre) estimates than that required for 'mudding' (97.2 and 78.8 hrs./acre respectively). However, non-owners' estimates of time required again appear on the whole to be higher than those of owners. The lower time requirement indicated by owners in these two cases may be accounted for to some extent by the possible emergence of scale economies in the operations in question on the larger size of holdings they operate.[4]

Comparisons can readily be drawn between the tillage work rates indicated in Table 3.2.1 and those commonly adopted in farm power planning in Sri Lanka:

- the performance of 4wt, at some 1.5 acres of full land preparation per 8 hour day, is lower than performances indicated elsewhere. For instance, the National Institute of Agricultural Engineering[5] estimates that at a tractor speed of 3.1 mph and a cultivation width of 1.09 yd. the area cultivated in a single pass in an eight hour day will be 9.9 acres (at 100% field efficiency). Full land preparation in Sri Lanka involves a double pass, so that this will be reduced to 5 acres/day, but for only 1.5 acres/day to be achieved (Table 3.2.1) field efficiency must be as low as 30%.[6] The FAO Farm Power plan estimated a rather higher performance of 2.0 acres/day on the basis of published field trials,[7] as do various other sources.[8] The low performance of 4wt observed in this study is almost certainly the consequence of the subdivision of farms on major irrigation schemes into large number of small liyaddes[9] which facilitate water control but necessitate frequent turning by

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[1] Collected in Schedules A0 and A10 (see Appendix 1).

[2] The range across study locations.

[3] A practice universally adopted at Kaudulla, only slightly at Padaviya and not at all at Uda Walawe.

[4] Owners' and non-owners' holding sizes are compared in Tables 3.4.1-3.4.2. Owners' work rate estimates are derived from a combination of their own work on these larger holdings and custom work on the smaller holdings of non-owners.

[5] Personal communication 24.2.82.

[6] For further information on field efficiency from experimental work in Sri Lanka see Appendix 3.6.

[7] Including Pillainayagam, 1972.

[8] Including Hewavitharana, 1970.

[9] See Glossary.

draught power, which places the relatively cumbersome 4wt at a particular disadvantage. This problem is discussed at lenth in Section 3.3 below.

- similarly, for 2wt tilling, the estimate of 0.58 acres per day is slightly lower than that commonly adopted[1] of 0.67 acres/day. Again, much of the explanation for this discrepancy is likely to lie in the higher proportion of time lost in turning within liyaddes in major irrigation schemes compared with experimental conditions.

- comparisons between buffalo tillage rates derived from this and from other studies are complicated by the widespread practice of at least two distinct methods of buffalo tillage,[2] which differ widely in their work rates. Even so, the estimates of buffalo performance used hitherto in farm planning in Sri Lanka are higher than the 0.1-0.125 acres per 5 hour day for ploughing and 0.07 acres per day for mudding derived from Table 3.2.1 and Appendix 3.3. For instance, Parker (1979) estimates 0.3 acres per day for ploughing, and FAC (1980) estimate 0.156 acres per day as a national average across ploughing and mudding techniques. The small size of liyaddes in major colonisation schemes is unlikely to impose substantial constraints on buffalo performance, and the work rates derived from the present study may be underestimates for two reasons: first, an element of levelling appears to have been incorporated in tilling, and has proved impossible to eliminate from the data. Thus, 'mudding' as a method of tillage is followed by only 5.5 buffalo hours/acre for levelling,[3] whereas buffalo ploughing requires 15.8 hours of buffalo levelling.[3] Second, other sources[4] have assumed that buffalo are capable of 5 hours of sustained work per day. These, however, will be interspersed with short rest periods, and it seems likely that the calculation of buffalo work rates from our data will have included a large element of rest time whereas other estimates do not. The buffalo records from our data typically show that 6-9 hours per day were spent in the field, of which only perhaps 5 were spent actively in tillage, the remainder being rest time. The calculation of work rates on the basis of gross time spent in the field will clearly indicate a lower performance than that based on net activity time.

In summary, the tillage performance of tractors in major irrigation schemes appears to be lower than work rates commonly used in farm planning in Sri Lanka. This may be attributable to some overestimate derived from the better operating conditions on experimental stations of their potential performance under field conditions. It is suggested, in particular, that the uniformly high density of liyaddes in our study locations is a major reason for low 4wt field performance. On the other hand, there are reasons to suspect that the buffalo performance rates derived here are underestimates, and throughout the remainder of this study, the FAO rate of 0.15 acres/pair/day is adopted.

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[1] By e.g. FAO (1980)

[2] i.e. ploughing and mudding - see Table 3.2.1.

[3] The relationship between power (and labour) time required for various methods of tillage and that required for subsequent operations is discussed in more detail in Appendix 3.2.

[4] Especially FAO (1980)

3.3. Paddy Farm Size in Relation to Type of Farm Power Used

1. Size of holding

Powerful theoritical arguments postulate a higher use of mechanised power with increasing size of farm:

For owners of draught power, the high performance capacity of a tractor is likely to be more fully employed the larger is the owner's farm. With larger farms, the more likely it seem a prior t hat individual field sizes will be large enough to permit efficient tractor operation requiring a minimum of turning time. Again the larger the farm, the more complex becomes the management of non-mechanised technologies involving large hired labour gangs particularly when crop operations demand highly seasonal inputs of labour.

For those who hire in farm power the first of these arguments does not apply but sufficient grounds remain to suggest a correlation between farm size and the degree of mechanisation. Owners and non-owners of farm power are considered in turn.

In Table 3.3.1 we compare the lowland paddy farm sizes[2] of non owners by the type of power they hire for tilling. This operation is the most costly and, in terms of timing, is the most significant in the cultivation calendar. It appears to have been the first agricultural operation in Sri Lanka for which the attempt was made to relieve the drudgery of human effort by the application of first animal, and subsequently, mechanical power.[3] It is therefore the most appropriate operation for testing hypotheses which suggest a tendency for larger farms to be more heavily mechanized.

The pooled data for all locations (Table 3.3.1) indeed show a tendency for farm acreage to be larger with increasing levels of mechanization, but the difference between 4 WT and 2 WT is not significant whereas it is between 2WT and buffalo and between 4WT and buffalo. The date therefore appear to be breadly consistant with our hypothesis, though the fact that the differences are small (and in one case, non-significant) is remarkable and may be taken to reflect small farm sizes relative to the daily tillage potential of 4WT. We need not reject our hypothesis: for non-owners it may simply be the case that whateverscale advantages exist donot come strongly into force within the relatively narrow range of lowland paddy holding sizes observed in irrigated ssttlements in the Dry Zone.[4]

For owners, the differences in paddy holding size by type of power owned are only slightly more marked. They rise with increasing technology levels from buffalo through 2WT to 4WT. Further the farm size of each of the three

1. In irrigated paddy farming the size of field is determined largely by considerations of topography and water control. The more undulating the land, the smaller will be liyaddes for any given standard of water control and size of farm. Conversely, the larger the farm the greater the potential for extending individual liyaddes along contours without detriment to water control.
2. For a digression on methodology see Appendix 3.3
3. Siriweera, (1981).
4. The analysis is extended to include operations other than land preparation in Appendix 3.1

TABLE 3.3.1: NON - OWNER SAMPLE: MEAN SIZE OF LOWLAND PADDY HOLDING[1] BY LOCATION AND TYPE OF DRAUGHT POWER USED FOR TILLING[2]

Non-Owners Hiring in	UDA WALAWE Acres			KAUDULLA Acres			PADAVIYA Acres			ALL LOCATIONS Acres
	Top	Tail[3]	All	Top	Tail	All	Top	Tail	All	All
4wt	-	0.59 [4]	0.59	5.98	4.25	4.83	3.37	1.60	3.07	3.42
		(0.00)	(0.00)	(0.00)	(1.60)	(0.54)	(0.13)	(0.22)	(0.22)	(0.30)
		(1)[5]	(1)	(1)	(2)	(3)	(10)	(2)	(12)	(15)
2wt	2.36	2.88	2.39	3.02	2.77	2.87	3.11	3.40	3.20	2.70
	(0.15)	(0.00)	(0.14)	(0.14)	(0.71)	(0.43)	(0.56)	(0.76)	(0.44)	(0.18)
	(18)	(1)	(19)	(2)	(3)	(5)	(7)	(3)	(10)	(34)
Buffalo	2.27	1.45	1.77	2.16	2.04	2.12	2.79	2.35	2.54	2.21
	(0.23)	(0.18)	(0.16)	(0.22)	(0.18)	(0.38)	(0.38)	(0.22)	(0.29)	(0.11)
	(7)	(11)	(18)	(29)	(13)	(42)	(15)	(21)	(36)	(96)

Notes:
1. The lowland paddy holding includes irrigated land which is owned, allotted or rented in (land type categories 1-4 on Schedule 1), but excludes any land officially designated as highland in the blocking out of these settlement schemes, although it may occasionally be illicitly irrigated by pumping from channels (or, at Kaudulla, by a combination of gravity and pumping). The irrigated lowland holding is selected because it appears central to farm power use decisions. Paddy grown on highland is, in any case, only 13% of the total paddy area for the above farmers.
2. "Tilling" is defined to include first and second ploughings but not levelling. For buffalo, it includes both ploughing and trampling ('mudding'). In this and subsequent tables only those observations are included in which the power type in question is the sole one used. For instance, a case in which both 4wt and 2wt were used in ploughing would be excluded from the analysis. This has the disadvantage of reducing the degrees of freedom, since, for instance, almost half the sample of non-owners used a mixture of power types in ploughing, but does appear to be the only way of avoiding bias in the analysis.
3. The allocation of sample farmers into top and tail categories is discussed in Appendix 1.
4. Standard error.
5. Number of observations. These are smaller than the numbers of observations recorded for the plot wise analysis of labour use etc. (Appendix 4.), since some farmers operated several plots (for a definition of 'plot' see Appendix 3.). Of the observations recorded in this table, 15% operated more than one lowland paddy plot (less than 1% operated more than two), the practice being more frequent at Kaudulla than elsewhere (27% of observations, as against 13% at Padaviya and 0% at Uda Walawe). The practice was also slightly more frequent among users of 4wt than others.

owner categories is significantly larger than that of those who hire in the corresponding power type (Table 3.3.2). Thus, whilst the farm size data for non-owners only weakly support the hypothesis of increasing farm size with increasing technology levels, the data for owners provide rather stronger evidence that this is indeed the case.

TABLE 3.3.2: OWNER SAMPLE: Mean Size of Lowland Paddy Holding[1] by Type of Power Owned

	UDA WALAWE	KANDULLA	PADAVIYA	ALL LOCATIONS
4wt Owners	2.50 (0.69)[2] (19)[3]	5.09 (0.78) (19)	9.11 (2.07) (18)	5.50 (0.10) (56)
2wt Owners	2.25 (0.54) (23)	4.53 (0.53) (26)	5.52 (0.99) (23)	4.12 (0.10) (72)
Buffalo Owners	1.68 (0.30) (19)	4.95 (0.61) (17)	3.77 (0.27) (20)	3.42 (0.18) (56)

Notes: 1. As for Table 3.3.1.
2. Standard Error.
3. Numbers of Observations.

In cases where an individual used more than one type, he was allocated into the highest horsepower category. Thus, the highest of a 2wt and buffalo would be regarded as a 2wt owner throughout this report.

2. Size of Liyaddes

Our analysis above indicated that the tendency for higher levels of mechanisation to be associated with larger holding sizes was not strong, and attributed this to the small overall size of holding and the narrow range within which they varied across the samples. The argument is expanded here to embrace the physical layout of paddy farms in relation to the type of draught power used.

In theory the potential performance of a 4wt will be used to good effect only if there is an unbroken supply of power to the implement. Frequent stopping, for instance in order to change direction or to move from one field to another, interrupts the operation and causes a reduction in overall efficiency. Ideally, therefore, fields should be large enough to keep turning and field changes to a minimum. The need to minimise the non-productive running time of high performance machinery has, no doubt, contributed to the large size of fields in the Canadian and American cereal belts. In Europe, where the scale of machinery is more comparable with the 4wt used in many parts of Asia, field sizes are still frequently within the tens or hundreds of acres.

We have seen (Table 3.3.1) that paddy farm sizes in Sri Lanka irrigated settlements are normally less than 5 acres, which in itself causes concern for the use-efficiency of 4wt. A factor of at least equal importance, however, is the subdivision of paddy farms into sub-plots ('liyaddes') for water control purposes. Ploughing commonly takes place within the boundaries (bunds) of these liyaddes, and so their size is of critical importance to the use-efficiency of tractors.[1]

As part of the non-owner survey, individual paddy fields were measured and the number of liyaddes counted, to permit calculation of the number of these smallest land units per irrigated acre. Comparative data for hirers of 4wt, 2wt and buffalo are presented in Table 3.3.3. Two points are immediately striking in these data: first, that liyaddes, on average, are less than one tenth of an acre in size, second, that there is no consistent or significant tendency for the use of tractors to be associated with larger-sized liyaddes than the use of animal draught. Overall, 4wt users have 11.17 liyaddes/acre, against 11.51 for 2wt and 13.99 for buffalo users.

It seems clear that the use of tractors has, in practical terms, neither encouraged nor permitted the consolidation of heavily subdivided fields into units of larger size. With such highly fragmented fields as these a low effective use of tractor draught, and consequent high input of running time per acre (Table 3.2.1) must come as no surprise.

A counter argument may be advanced that it is the ownership and not the hiring of tractors which may lead to consolidation of these fragmented paddies. Comparable data on the density of liyaddes in owners' fields are not available, but this is not consistent with the repeated field observations of the study team, which suggest that there is no difference in liyadde density on the irrigated paddy plots of owners and non-owners. Furthermore, as our data have already suggested (Part 1 Report, Chapter 3) the proportion of 4wt time in farm operations allocated to hiring out is three times greater than that reserved for own use. It is therefore the performance of tractors on non-owners[2] fields which will be by far the stronger determinant of their overall use-efficiency.

Indeed there is no <u>a priori</u> reason to expect substantial reduction in the degree of subdivision of paddy fields into liyaddes with the advent of mechanisation. Bunding is primarily a water control measure, and its

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[1] The threat posed to efficient use of mechanical power by land fragmentation, whether a result of subdivision on inheritance or of small liyaddes designed to suit topographical variations, was recognised in the very infancy of mechanisation in Sri Lanka: S. G. Taylor, Director Irrigation, discussed it at length in his Administration Report for 1945 (abstracted in Ceylon Daily News, 28th October, 1946). A report by FAO advisers on farm mechanisation in 1953 (abstracted in CDN, 6.11 and 19.12.53) indicated up to 23 liyaddes/acre, prompting the Ministry of Lands to declare that future colonisation schemes would be laid out with only 4 liyaddes/acre. Yet the high density continued and was advanced by Brohier (1975, pp. 148-150) as the principal constraint to mechanisation in major colonisation schemes, and over 30 years later liyaddes are still, on average, under one-tenth of an acre in size in areas where 4wt are widely in paddy cultivation.

[2] The situation is different for rainfed paddy such as that grown on the peripheries of Padaviya, where bunding is less frequent and a density of some 2-5 liyaddes/acre can be observed. At the other extreme, the authors have several times observed 4wt tilling irrigated paddy liyaddes so small that the tractor has been forced to reverse the full length of the liyadde to start a fresh traverse, there being insufficient space to turn.

TABLE 3.3.3: NON-OWNER SAMPLE: NUMBER OF LIYADDES[1] PER ACRE BY TYPE OF POWER HIRED FOR TILLING,[2] SUB-AREA WITHIN LOCATION[3] AND LOCATION (Maha season only).

Those Hiring in	UDA WALAWE Top	UDA WALAWE Tail	KAUDULLA Top	KAUDULLA Tail	PADAVIYA Top	PADAVIYA Tail
4wt	-	5.00	9.48	10.89	9.71	22.69
	-	(0.00)[5]	(0.00)	(2.07)	(0.89)	(0.71)
	-	(1)[6]	(1)	(2)	(10)	(2)
2wt	14.07	41.67	6.44	9.81	12.88	6.72
	(1.03)	(0.00)	(1.43)	(1.10)	(1.30)	(0.51)
	(18)	(1)	(2)	(3)	(7)	(3)
Buffalo	15.22	48.10	5.29	10.31	10.81	14.66
	(1.74)	(7.37)	(0.64)	(0.90)	(1.73)	(3.87)
	(7)	(9)	(14)	(9)	(15)	(19)

Notes:
1. Defined as the smallest bunded unit of land within an irrigated paddy field.
2. "Tilling" is defined at the foot of Table 3.3.1.
3. As defined in Appendix 2.2.
4. The number of observations for buffalo users is slightly lower than in Table 3.3.1, since 14 observations had missing values.
5. Standard error.
6. Number of observations.

frequency will to a great extent be determined by topography. Thus as Uda Walawe where slopes are steeper than at the other two locations, the density of liyaddes is, on the whole, significantly higher than for comparable combinations of power type and sub-area elsewhere. Kaudulla enjoys the lower density of liyaddes, but, remarkably, non-owners at Kaudulla display a relatively low use of 4wt power and high use of animal draught (Table 3.1.1). Consistent with the view that bunding is seen as a prerequisite of adequate water control, are the generally higher densities of liyaddes at the tail ends, where its supply tends to be irregular, compared with the top ends, there being little difference in topography within two locations (Padaviya and Kaudulla).[1]

3.4: Farm Power Ownership and Land-use Intensity

In our introductory section it was suggested that a potentially powerful productive characteristic of mechanisation lay in its capacity for more intensive land use. This postulate is now examined against our data. For convenience, it may be broken down into the following hypotheses:

i) That tractors have permitted additional land to be cultivated and have so made a net contribution to cultivated acreage even if this is only at existing levels of input intensity and yields.[2]

ii) That mechanisation has permitted a switch to varieties of existing crops which generate higher returns to land through, for instance, higher yield potential or higher unit value.

iii) That mechanisation has facilitated a change in the crop mix towards crops giving higher returns to land.

iv) That mechanisation has permitted the earlier sowing of crops with benefits in terms of higher yield or higher net returns through more favourable market conditions at harvest.[3]

v) That mechanisation has permitted an increase in annual cropping intensity on existing cultivated land.

Let us expand on these propositions in turn:

1. Mechanisation and the gross area cultivated

The relevance of data collected in the present study to a testing of this hypothesis is limited by the fact that samples were drawn from major irrigation schemes, where the scope for expanding cultivated acreages is limited by the fact that the schemes chosen are large, and

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[1] Significant for buffalo users at Kaudulla.

[2] At first sight this does not appear to be a land-intensifying effect. It does, however, represent an intensification where land would otherwise be totally unutilised, as is still the case in many parts of the Dry Zone.

[3] But this will be of net benefit to the national economy only if it produces higher revenues at the border. With internal trade its effects will be purely distributional.

commonly surrounded by land already cultivated or otherwise reserved (for forestry). Whilst the prospects for cultivation of new land by tractor owners are thus not as simple as they might be in, for instance, the sparsely populated areas around Vavuniya, they remain nonetheless substantial in some areas. The data can be expected to shed some light on the extent to which this scope has been exploited. Whilst they are directly relevant to the large concentrations of tractors in major irrigation, they are not designed as national sample statistics of net increases in cultivated area attributable solely to tractors.

Neither at Uda Walawe nor at Kaudulla is there abundant new land available for cultivation immediately adjacent to the irrigated area where the study was based. No substantial expansion of highland acreages by tractor owners is to be expected in these areas, and as the data suggests (Tables 3.4.1 - 3.4.2), little has taken place. At Padaviya, however, the availability of land has been exploited both legally[2] and illicitly[3] by, principally, tractor owners. This is reflected in the data on operated highland[4] acreages in Table 3.4.1, Padaviya 4wt owners having an average highland acreage of 3.09, as against 1.59 at Kaudulla and 0.30 at Uda Walawe.[5] The highland acreages for 2wt owners are in all cases smaller, but again larger at Padaviya than elsewhere. Rainfed paddy is virtually the sole crop grown on these lands adjacent to Padaviya, whereas grain legumes (especially black gram) are commonly found on similar land further to the west (i.e. in the neighbourhood of Vavuniya).

In these cases, tractor cultivation appears to have increased the gross area under cultivation in two ways: first, it has permitted more rapid conversion of hitherto uncultivated land into agricultural production than would have been the case with human labour alone. Second, more thorough cultivation and use of herbicides on tractor cultivated land has permitted this to remain under crops on a permanent basis whereas hand-cultivated chena still commonly requires a fallow cycle of several years.[6] The production effect is limited, though, to this more rapid spread of cultivation into fallow lands. Apart from tillage methods,

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[1]Carr (1975, p.286) drawing on samples of tractor owners from areas outside major irrigation, comments on the large re-distributive effect on land holdings, but does not mention additional cultivation of new land. It may, therefore, have been insignificant even in areas relatively amenable to it.

[2]Through land allotments made through the Land Commissioner's Department and, more recently, through the District Government Agent.

[3]Through encroachment onto uncultivated Crown land which seldom attracts penalties and is periodically 'regularised'.

[4]Calculated as the difference between all operated land and operated paddy land.

[5]A similar phenomenon has been noted, for instance, by Carr (1975) in areas on the eastern coast.

[6]The duration of the fallow cycle varies according to population pressures. In parts of the southern Dry Zone, for instance, cotton and some food crops are cultivated by hand under short fallow cycles, and occasionally even on permanently hand cultivated land with no fallow (Farrington, 1979).

TABLE 3.4.1: OWNER SAMPLE: MEAN ACREAGE OPERATED BY TYPE OF LAND, LOCATION, POWER TYPE AND SEASON (Whole Sample)

Owners of	Season	IRRIGATED LOWLAND OPERATED[1]										ALL LAND OPERATED[2]									
		UDA WALAWE			KAUDULLA			PADAVIYA			ALL LOCATIONS			UDA WALAWE			KAUDULLA			PADAVIYA			ALL LOCATIONS		
		Acres Mean	S.E.	No.of Cases	Acres Mean	S.E.	No.of Cases	Acres Mean	S.E.	No.of Cases	Acres Mean	S.E.	No.of Cases	Acres Mean	S.E.	No.of Cases	Acres Mean	S.E.	No.of Cases	Acres Mean	S.E.	No.of Cases	Acres Mean	S.E.	No.of Cases
4wt	Maha	2.50	0.69	19	5.09	0.78	19	9.11	2.07	18	5.50	0.10	56	2.80	0.71	19	6.67	0.93	19	12.70	2.70	18	7.13	0.89	56
	Yala	2.97	0.72	19	2.54	0.59	19	0.00	0.00	18	1.84	0.51	56	3.03	0.73	19	3.01	0.58	19	0.00	0.00	18	2.05	0.52	56
	ci[3] %	219%			150%			100%			133%			208%			145%			100%			129%		
2wt	Maha	2.25	0.54	23	4.53	0.53	26	5.52	0.99	23	4.12	0.10	72	2.53	0.57	23	5.43	0.53	26	8.10	1.46	23	5.36	0.58	72
	Yala	2.00	0.44	23	1.97	0.32	26	0.00	0.00	23	1.35	0.48	72	2.33	0.48	23	2.34	0.34	26	0.30	0.26	23	1.68	0.21	72
	ci %	189%			143%			100%			133%			192%			143%			104%			131%		
Buffalo	Maha	1.68	0.30	19	4.95	0.61	17	3.77	0.27	20	3.42	0.18	56	3.29	0.99	19	6.23	0.55	17	4.80	0.29	20	4.72	0.09	56
	Yala	1.26	0.26	19	2.12	1.20	17	0.10	0.10	19	1.13	0.47	55	2.58	1.02	19	2.71	1.07	17	0.10	0.11	19	1.76	0.18	55
	ci %	175%			143%			103%			133%			178%			143%			102%			137%		
All	Maha	2.15	0.31	61	4.82	0.40	62	6.00	0.76	61	4.45	0.06	184	2.86	0.43	61	6.03	0.46	62	8.20	1.03	61	5.70	0.39	184
Owners	Yala	2.07	0.30	61	2.19	0.30	62	0.03	0.03	60	1.44	0.03	183	2.63	0.42	61	2.65	0.30	62	0.10	0.11	60	1.82	0.23	183
	ci %	182%			145%			101%			132%			192%			144%			101%			132%		

Notes:
1. Includes land to which de jure cultivation rights are held and which is cultivated plus land legally or illicitly rented in or encroached which is cultivated. Excludes any land rented out or otherwise not cultivated by the respondent. For both owners and non-owners observations at the tail end of Uda Walawe include the cultivation of non-paddy crops on land designated as irrigated lowland. This official term is redundant in many cases, since irrigation water rarely arrives.
2. The same definition applies as for note 1, with the exception of the final remarks.
3. Cropping index = maha + yala acres ÷ maha acres x 100.
Since the base on which the ci is calculated (i.e. the maha acreage) varies by location and by power type, the overall ci's given under 'All Locations' do not necessarily give the same rankings as the individual locations, are examined, 4wt owners generally crop more intensively.

Tables 3.4.1 and 3.4.2 should be read in conjunction with thr analysis of changes in operated holding sizes over time presented in Appendix 5.4.

TABLE 3.4.2: NON-OWNER SAMPLE: MEAN ACREAGE OPERATED BY TYPE OF LAND, LOCATION, SUB-AREA WITHIN LOCATION AND SEASON

Sub-Area	Season	IRRIGATED LAND OPERATED								ALL LAND OPERATED								IRRIGATED LAND OPERATED ALL LOCATIONS			ALL LAND OPERATED ALL LOCATIONS		
		UDA WALWE			KAUDULLA			PADAVIYA		UDA WALAWE			KAUDULLA			PADAVIYA							
		Acres Mean	S.E.	No.of Cases	Acres Mean	S.E.	No.of Cases	Acres Mean	S.E.	No.of Cases	Acres Mean	S.E.	No.of Cases	Acres Mean	S.E.	No.of Cases	Acres Mean	S.E.	No.of Cases	Acres Mean	S.E.	No.of Cases	Acres Mean	S.E.	No.of Cases
Top	Maha	2.55	0.17	20	2.50	0.35	19	2.76	0.24	20	2.81	0.24	20	2.99	0.39	20	3.83	0.34	20						
	Yala	1.83	0.29	20	1.61	0.29	19	0.00	0.00	20	1.87	0.28	20	1.61	0.29	19	0.00	0.00	20						
	ci %	172%			164%			100%			167%			154%			100%								
	Maha	2.10	0.18	20	1.77	0.37	19	3.17	0.26	20	2.50	0.18	20	2.95	0.35	19	4.58	0.35	20						
	Yala	2.00	0.19	20	0.51	0.11	19	0.00	0.00	20	2.40	0.22	20	0.77	0.16	19	0.00	0.00	20						
	ci %	195%			129%			100%			196%			126%			186%								
Tail	Maha	1.80	0.15	20	2.28	0.29	19	2.97	0.18	20	1.96	0.18	20	3.97	0.36	19	3.82	0.18	20						
	Yala	0.58	0.12	20	0.16	0.09	19	0.00	0.00	20	0.61	0.13	20	0.24	0.11	19	0.00	0.00	20						
	ci %	132%			107%			100%			134%			106%			100%								
	Maha	1.59	0.14	20	3.30	0.36	20	1.20	0.17	20	1.61	0.14	20	3.83	0.37	20	1.83	0.24	20						
	Yala	0.79	0.15	20	0.28	0.22	20	0.00	0.00	20	0.79	0.15	20	0.28	0.22	20	0.00	0.00	20						
	ci %	150%			108%			100%			149%			107%			100%								
All[4]	Maha	2.01	0.08	80	2.47	0.24	77	2.52	0.14	80	2.22	0.11	80	3.44	0.22	77	3.52	0.18	80	2.33	0.13	237	3.05	0.18	237
	Yala	1.30	0.12	80	0.64	0.20	77	0.00	0.00	80	1.42	0.13	80	0.72	0.14	77	0.00	0.00	80	0.65	0.11	237	0.71	0.10	237
	ci %	165%			126%			100%			164%			121%			100%			128%			123%		

See Notes below Table 3.4.1.

4. Since the designation of sub-areas for the non-owner sample is not entirely uniform across locations, only an overall acreage is presented under the all-locations category.

other aspects of cultivation remain largely unchanged. No net contribution to the value of agricultural output is therefore to be expected through a switch to crops of higher value or through any yield improvement on additional land brought into cultivation in this way.[1]

2. Higher yielding varieties

There is no reason to suppose that mechanisation has permitted a switch towards higher yielding varieties of the staple crop, paddy. Sri Lanka has a long record of the breeding and dissemination of, first, its own high yielding varieties and, later, of crosses between these and the varieties which are either highly responsive to favourable agronomic conditions or are resistant to such adverse conditions as salinity and iron toxicity. The small farmer adoption of three improved varieties is almost universal.[2] Analysis of data from our samples of owners and non-owners at all locations shows that there are no cases of cultivation of paddy varieties other than improved ones.[3]

3. Crop diversification

The search for diversification into crops offering higher potential returns to land or to irrigation water than paddy proves equally unrewarding (Tables 3.4.3 - 3.4.4). The non-owner sample achieved successful[4] cultivation of only 43.55 acres of non-paddy crops in maha, and 29.39 in yala, a mere 7% and 20% of the paddy acreages respectively. Comparable figures for the owner sample were 5.40 acres in maha and 8.25 in yala, an even poorer diversification record, at 1% and 3% of the paddy acreages in the respective seasons. An inter-location comparison reveals that Padaviya has the lowest degree of diversification. This is in spite of the fact that Padaviya was one of 11 major irrigation schemes selected for the Special Project Programme in 1968, a major component of which was the attempt at diversification away from paddy in yala season in order to increase the returns to irrigation water supplies which were particularly scarce in that season. The ineffectual performance of this programme in crop diversification and in the other aspect is evident in surveys conducted by Jogaratnam (1974).

Reasons advanced for lack of success in crop diversification over the last 2-3 decades range from the cultural and historical bond with paddy production (Abeyratne, 1956, 1962, 1967) to the more mercenary considerations of lower labour requirements and high returns to labour provided by paddy (Farrington, 1979), the higher sensitivity of non-

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[1] For instance, the 10 4wt owners at Pulmoddai (Padaviya) who cultivated exclusively rainfed paddy achieved a mean yield of 37.7 bu/ac, which is comparable with the yield commonly observed for hand cultivation of paddy in the Dry Zone under chena. For instance, a yield of 32 bu/ac under chena is reported by ARTI (1979b).

[2] Data supplied by the Central Rice Breeding Institute, Batalagoda, reveal that 83% of the national sown paddy area was under improved varieties in maha 1977-8 and 73% in yala 1978.

[3] Although, of course, these may in some cases have lost their line characteristics owing to inadequate inputs of fresh certified seed.

[4] Crop failures are excluded.

paddy crops to inundation (Ranatunga et al, 1981), and a host of market related requirements highly prone to disruption (Wijayaratna, 1981). For our locations, it is clearly only in those areas where irrigation supplies are inadequate for paddy production that serious attempts at the cultivation of non-paddy crops have been made. Thus it is at the tail end of Uda Walawe that over 80% of the area planted by non-owners to non-paddy crops is cultivated (Table 3.4.4).

4. The timing of cultivation

Our assessment of the timing of cultivation by owners and non-owners relies on two mutually supporting methodologies. On the one hand, profiles of labour input by week are available for non-owners, and by month for owners. These give a clear indication of the timing of peak activities, which can be checked against the raw labour input data (Schedule 1 - see Part 1 Report, Chapter 2.4) to verify the operations performed during the time periods in question. Second, fortnightly visits were made by the research staff to each location to supervise the work of field investigators, which involved traversing the length of each command area. This afforded a valuable opportunity to obtain a visual assessment of cropping progress, and a log was written up on each visit.

Labour profiles, and the corresponding crop operations are given in Figures 3.1 - 3.3 for all non-owners by location and in Figures 3.4 - 3.6 by location for the sub-sample of owners for whom farm records were kept. Peak labour activities clearly coincide with the operations of land preparation and harvesting/threshing in each case, with the exception of Padaviya owners (Figure 3.6), where the peculiar labour distribution is entirely attributable to the inclusion of some 4wt owners in Pulmoddai (i.e. outside the Padaviya command area), who grew paddy under non-irrigated conditions and planted their crop well ahead of the main irrigated crop.

Important differences in the timing of cultivation between locations are visible in these figures. Uda Walawe is slightly ahead of Kaudulla, and both are well advanced over Padaviya.[1] Differences between owners and non-owners within locations are not however apparent. The analysis was taken a stage further by disaggrating the labour profile of non-owners by sub-area within location, and of owners by type of power owned within location. Pressure of space prevents presentation of the 21 graphs thus derived. However, there did not emerge any differences in timing among owners and the only variations among non-owners appeared to be for those in the lower tracts at Uda Walawe and off scheme at Kaudulla to start their season some 2-3 weeks earlier than

[1] All locations had heavy rainfall in September-November, 1979, more than adequate for conventional mudland tillage. The delay at Padaviya in spite of these favourable conditions is symptomatic of a wider malaise at Dry Zone major irrigation schemes and has negative implications for attempts to advance and synchronise the cropping calendar. The reasons for this delay are the subject of further discussion in Appendix 3.4.

TABLE 3.4.3: OWNER SAMPLE: ACREAGES OF NON-PADDY CROPS CULTIVATED BY LOCATION AND TYPE OF POWER OWNED

	UDA WALAWE				KAUDULLA				PADAVIYA				ALL LOCATIONS			
	Maha		Yala		Maha		Yala		Maha		Yala		Maha		Yala	
	Crop	Acres	Crop	Acres	Crop	Acres	Crop	Acres	Crop	Acres	Crop	Acres	Crop	Acres	Crop	Acres
4wt Owners											61	0.50			61	0.50
											23	0.25			23	0.25
2wt Owners	41	3.00			23	0.10	61	1.50					41	3.00	61	1.50
													23	0.10		
Buffalo Owners							23	0.20	72	2.30			72	2.30	23	0.20
							61	5.80							61	5.80
All Crops		3.00				0.10		7.50		2.30		0.75		5.40		8.25

TABLE 3.4.4: NON-OWNER SAMPLE: ACREAGES OF NON-PADDY CROPS CULTIVATED BY LOCATION AND SUB-AREA WITHIN LOCATION

	UDA WALAWE				KAUDULLA				PADAVIYA				ALL LOCATIONS			
	Maha		Yala		Maha		Yala		Maha		Yala		Maha		Yala	
	Crop	Acres	Crop	Acres	Crop	Acres	Crop	Acres	Crop	Acres	Crop	Acres	Crop	Acres	Crop	Acres
Top					72	0.11	61	2.19	72	0.96						
					23	0.57	23	0.75	51	0.30						
	41	2.00	41	8.25	42	0.08			11	1.50						
					11	0.26										
					12	0.33										
					61	0.35										
Middle																
Bottom	61	0.91	61	7.22			61	2.00	12	0.45						
	72	0.69	72	3.84					72	0.29						
	21	21.62	52	3.75					23	0.23						
	41	9.64	41	0.39												
	11	2.91	21	1.00												
	14	0.14														
	12	0.06														
	42	0.10														
	23	0.05														
All Crops		38.12		24.45		1.70		4.94		3.73				45.55		29.39

Crop Codes: 11 = Kurakkan
12 = Maize
14 = Meneri
21 = Green gram
23 = Cowpea
41 = Gingelly (Sesame)
42 = Groundnut
51 = Tobacco
52 = Cotton
61 = Chillies
72 = Vegetables.

FIGURE 3.1: NON-OWNER SAMPLE - UDA WALAWE. Total Labour Input by week per farm (paddy only)
Mean size of paddy farm = 2.01 acres (maha)
1.30 acres (yala)

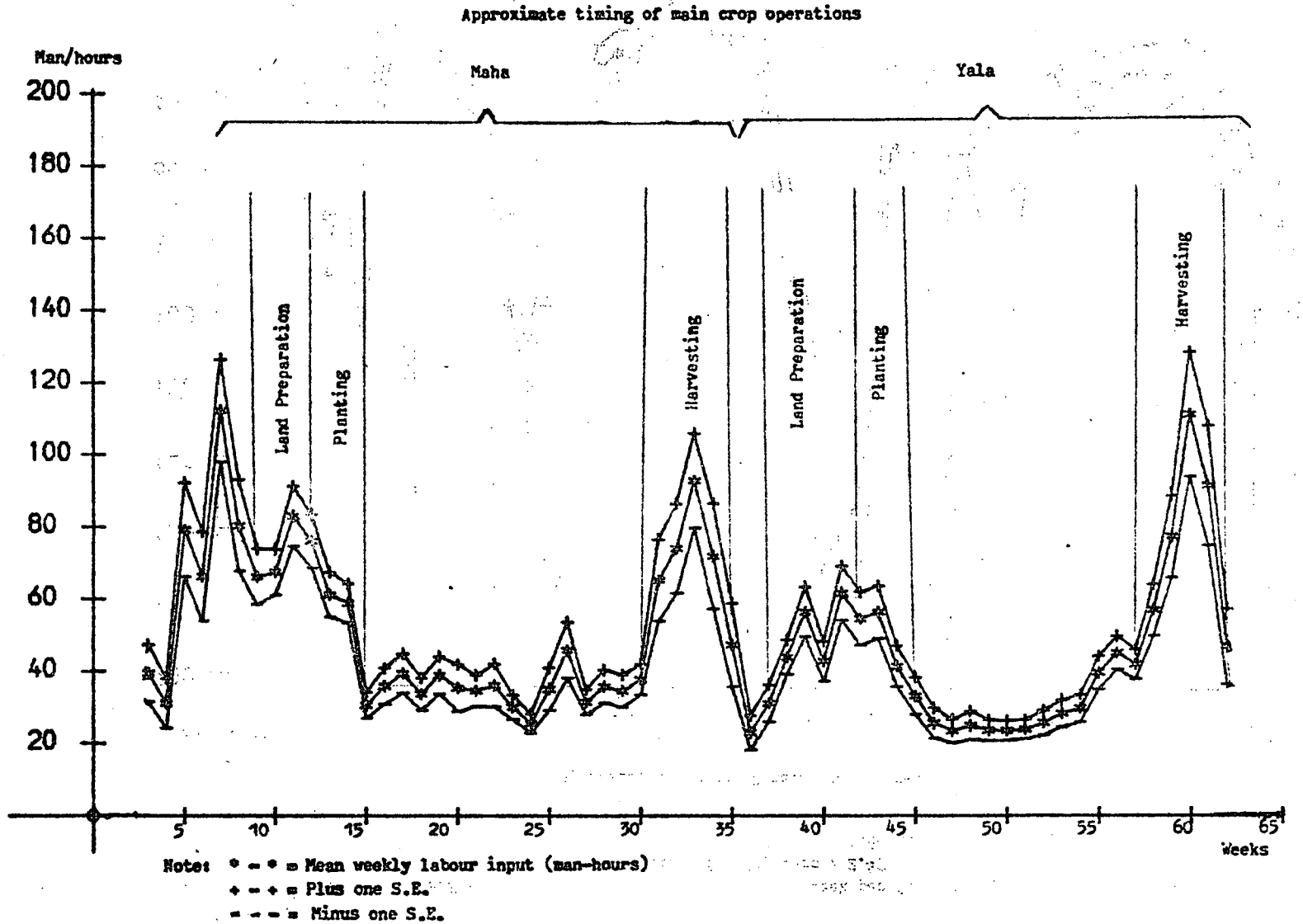
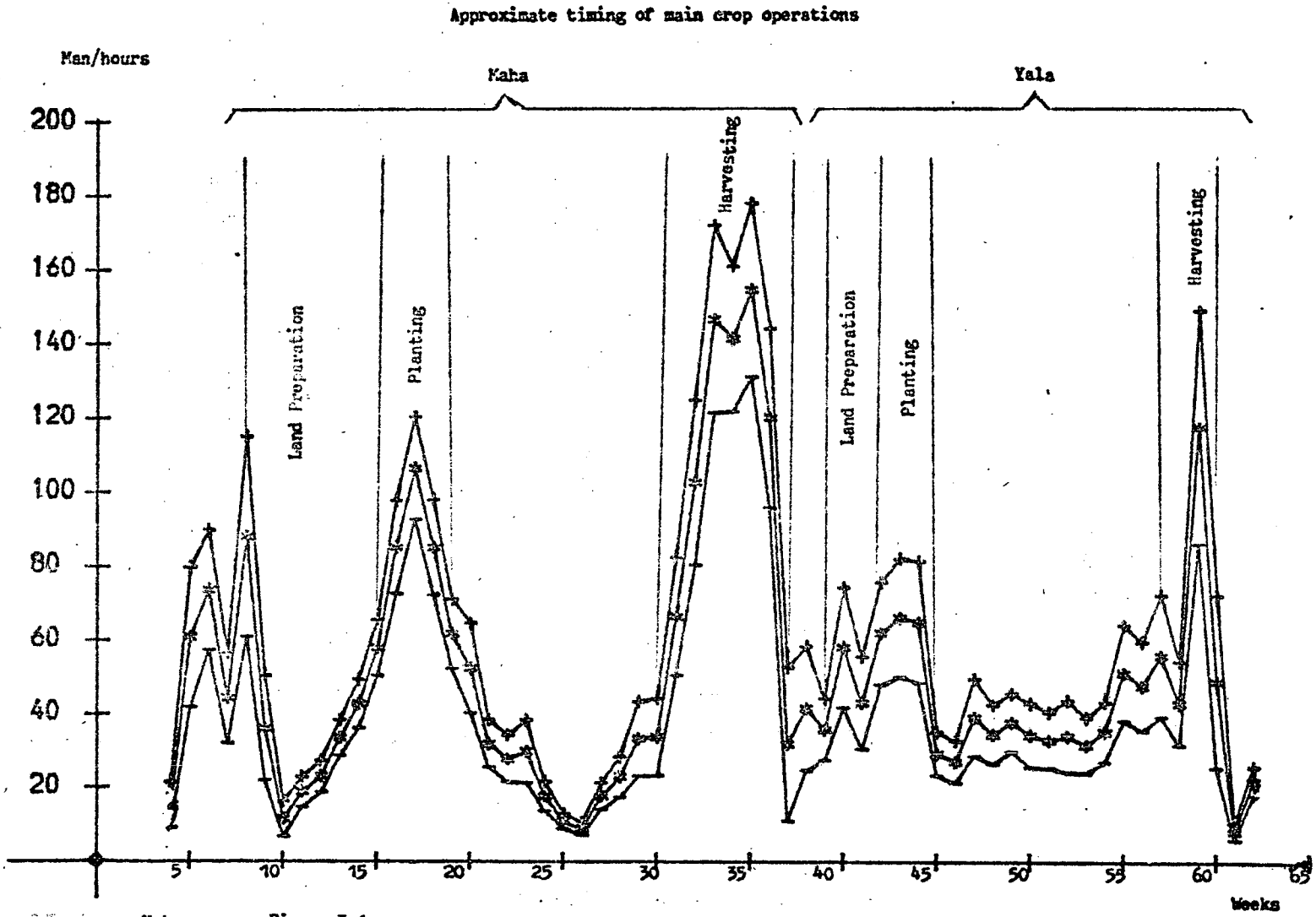
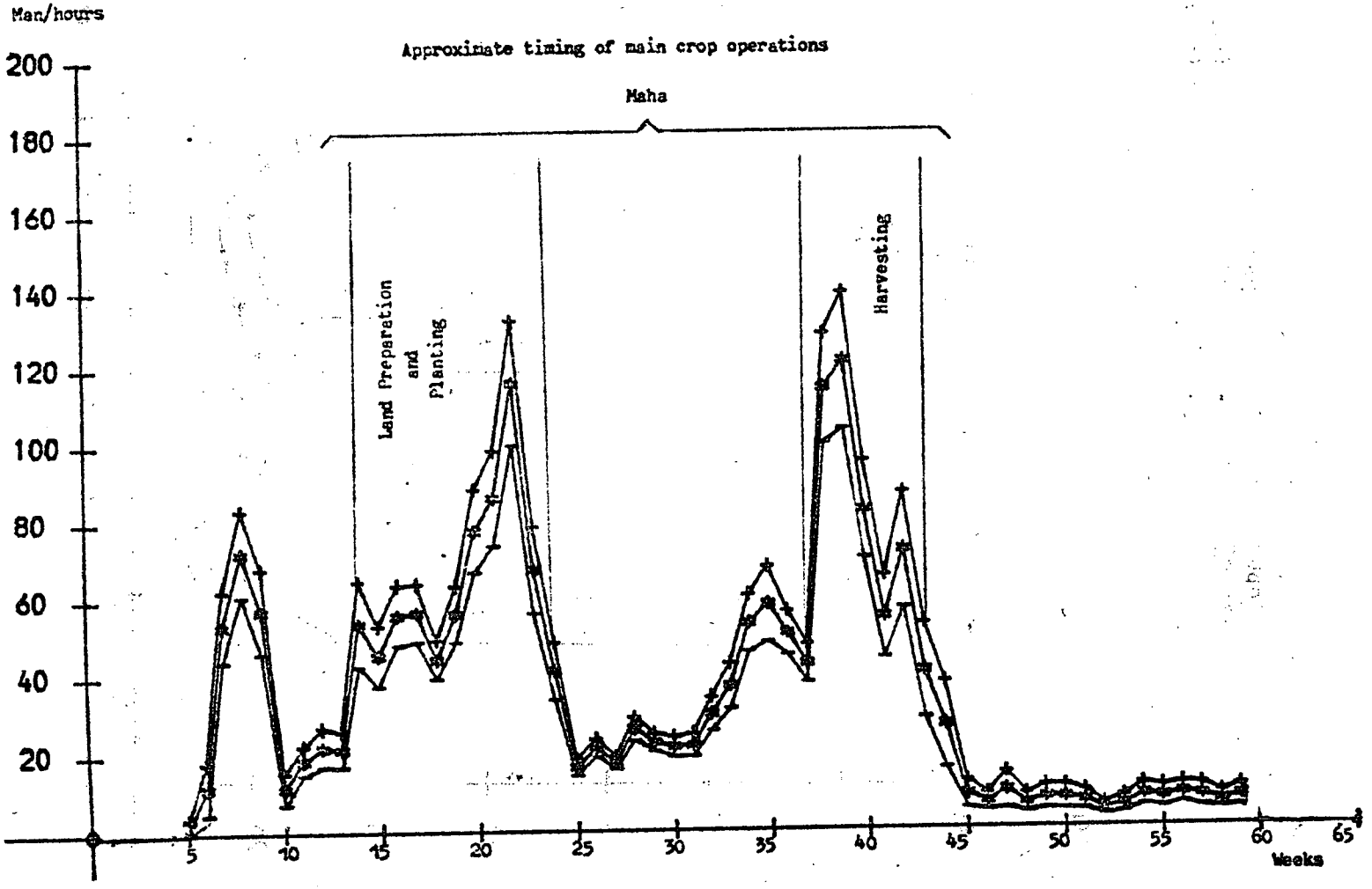


FIGURE 3.2: NON-OWNER SAMPLE - KAUDULLA. Total labour input by week per farm (paddy only)
Mean size of paddy farm = 2.47 acres (maha)
0.64 acres (yala)



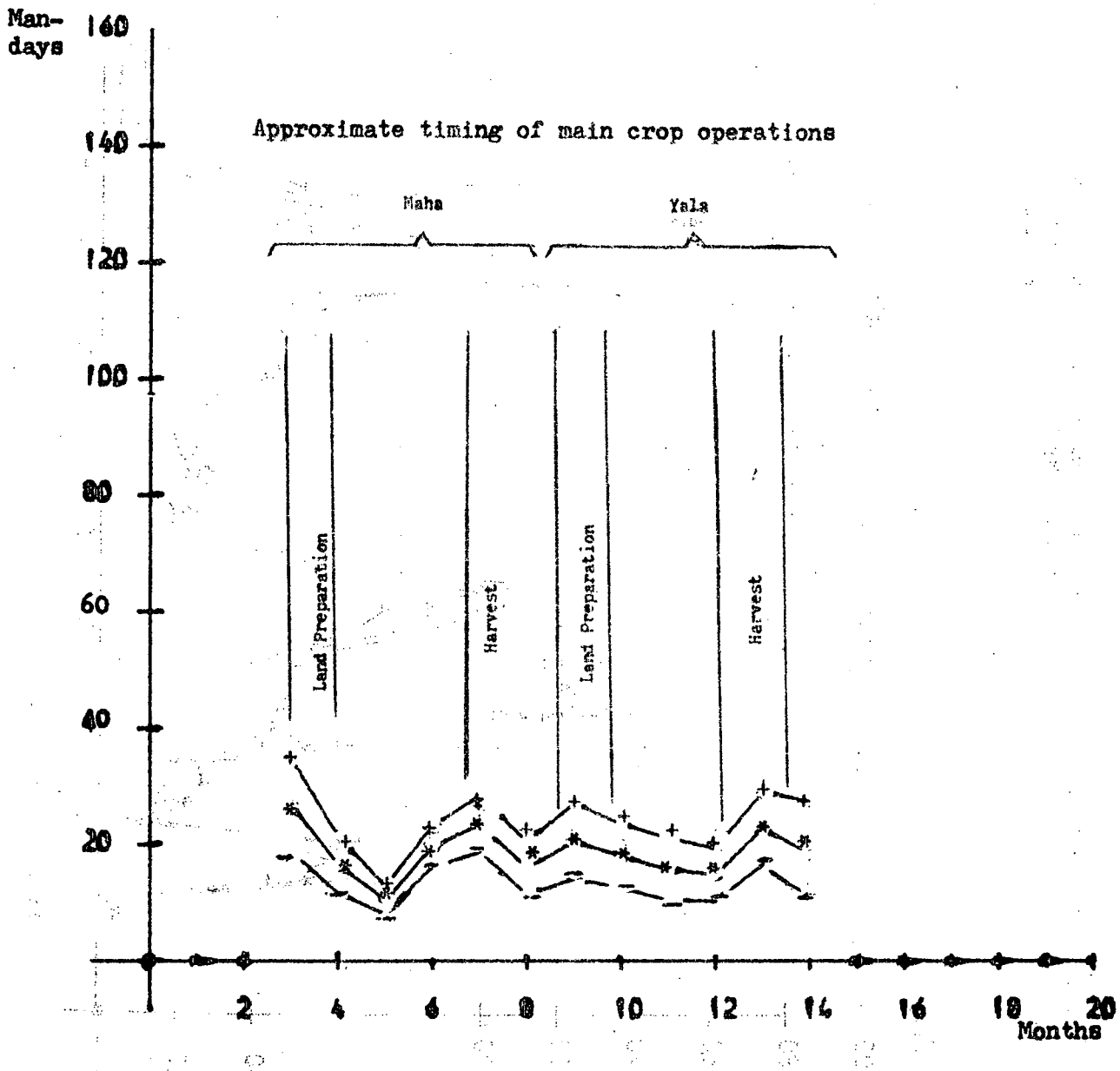
Notes as per Figure 3.1.

FIGURE 3.3: NON-OWNER SAMPLE - PADAVIYA. Total labour input by week per farm (paddy only)
Mean size of paddy farm = 2.52 acres (maha)
0.00 acres (yala)



Notes as per Figure 3.1

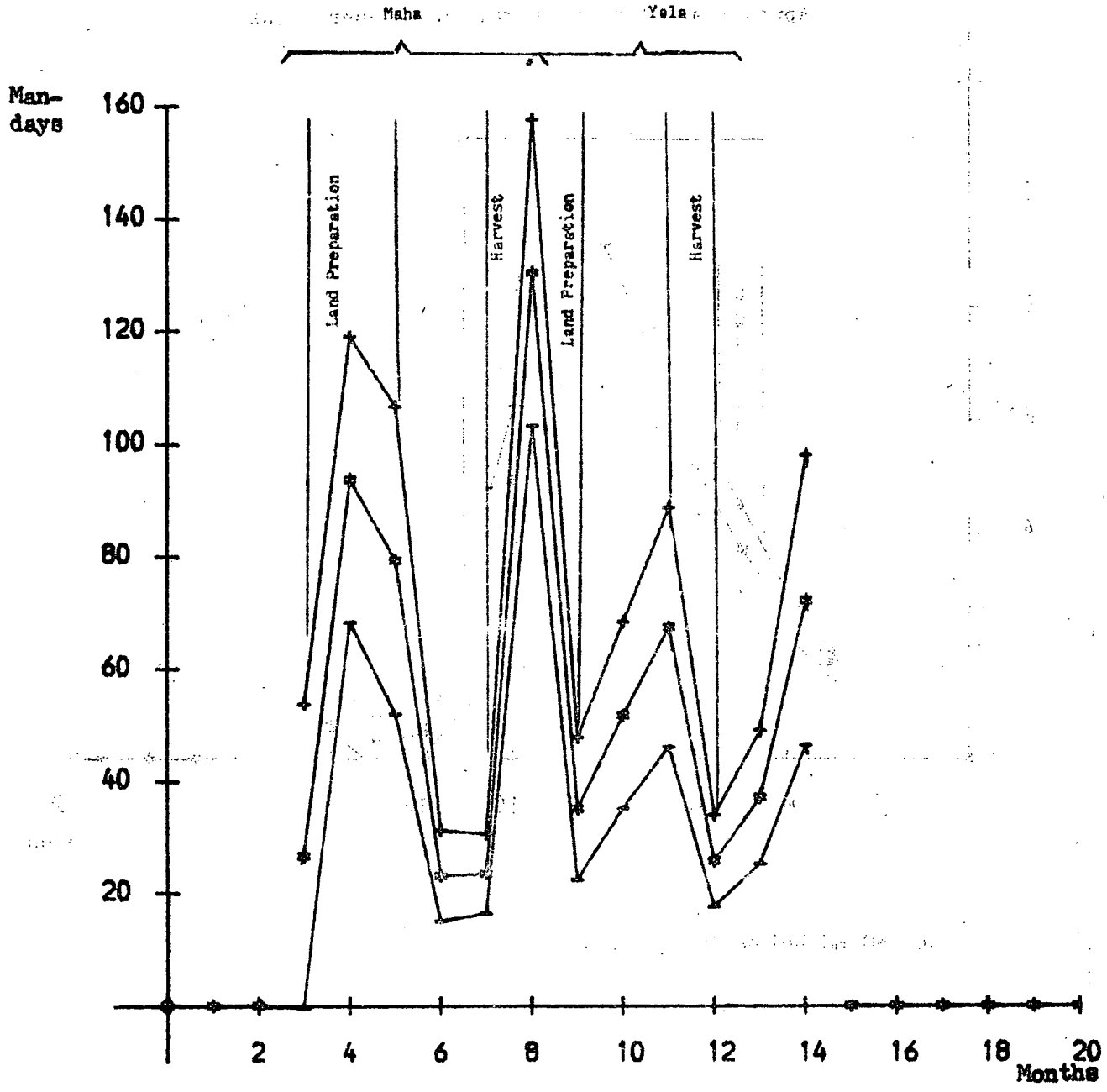
FIGURE 3.4: OWNER SAMPLE - UDA WALAWE
Labour inputs per farm (man-days) by month (paddy only)
Mean size of paddy farm operated = 2.51 acres (maha)
2.07 acres (yala)



NOTES: Month 1 = August, 1979.
* - * = Mean labour input.
+ - + / - - - = Confidence limit (+ and - one S.E. respectively).

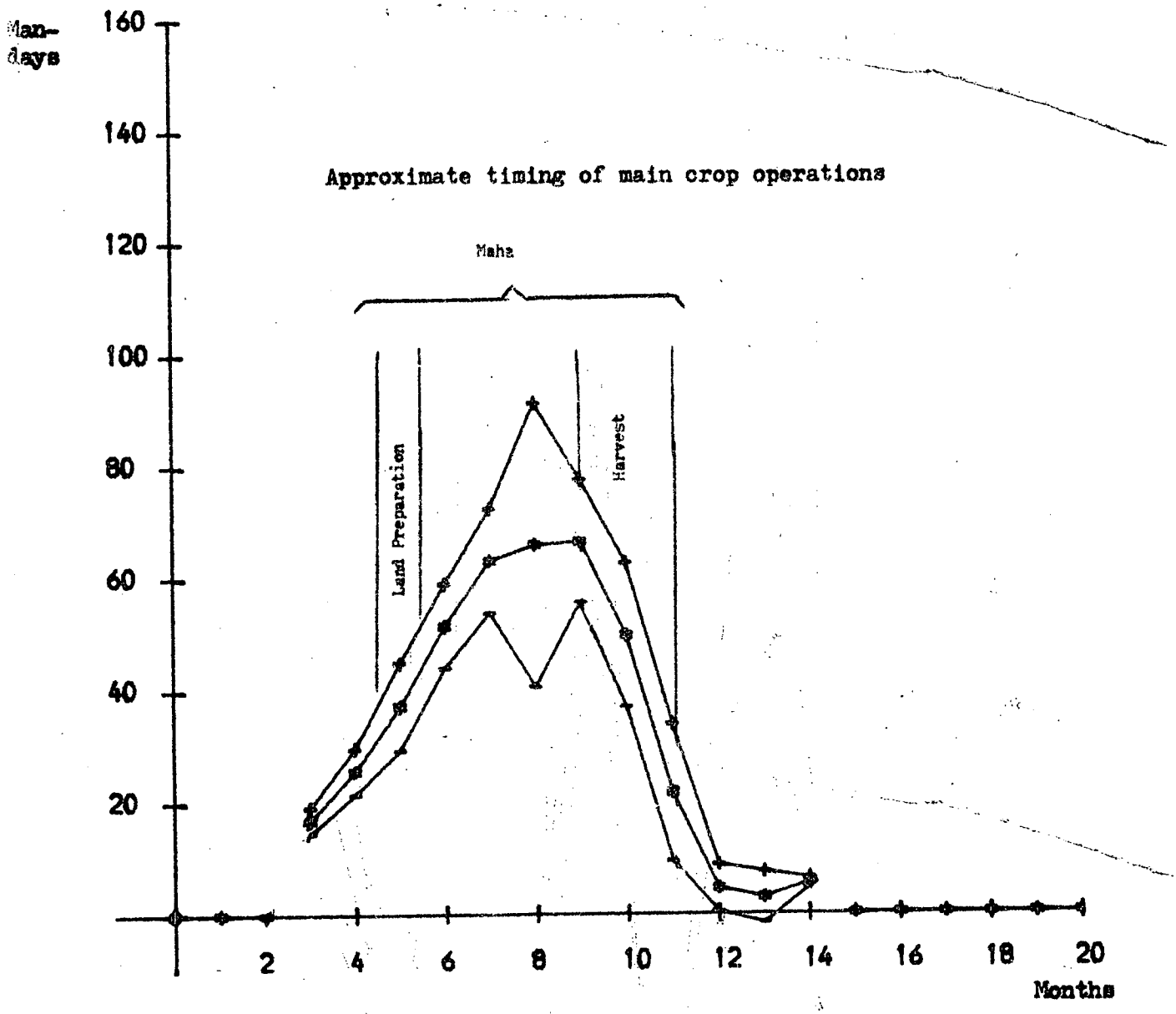
FIGURE 3.5: OWNER SAMPLE - KAUDULLA
Labour inputs per farm (man-days) by month (paddy only)
Mean size of paddy farm operated = 4.82 acres (maha)
2.19 acres (yala)

Approximate timing of main crop operations.



See NOTES below Figure 3.4.

FIGURE 3.6: OWNER SAMPLE - PADAVIYA
Labour inputs per farm (man-days) by month (paddy only)
Mean size of paddy farm operated = 6.00 acres (maha)
0.03 acres (yala)



See NOTES below Figure 3.4.

their colleagues in the upper tract. This pattern[1] prompts the hypothesis that those located at the tail ends who have a fair expectation from previous seasons of receiving enough irrigation water to grow paddy[2] realise that irrigation water will arrive later than at the top end (in a command area as long as Uda Walawe - approximately 20 miles in a straight line - water conveyance will take 10-20 days, depending on the need to fill such intermediate storage tanks as Chandrikawewa), and will be lower in quantity and less regular in supply. They may, therefore, attempt to use whatever advantage early rains may give (and these were particularly abundant in maha 1979-80) in achieving early land preparation.

Our alternative methodology, that of drawing on the crop-timing information contained in fortnightly supervisory visits, confirms the lack of variation among non-owners within locations, with the exceptions of tailenders at Uda Walawe and off scheme farmers at Kaudulla. The reports do not, however, contain enough detail on the plots of owners[3] to permit an assessment.

On the whole, our conclusion must be that there is no evidence of earlier cultivation by owners vis-a-vis non-owners, or of owners of tractors over buffalo owners. It is the differences in crop timing among locations which are of over-riding importance.

This is not to imply that tractors do not have the potential for more rapid cultivation of their owners' lands - given the small size even of owners' paddy holdings in relation to the tillage capacity of 4wt, there can be little doubt that earlier cultivation of owners' lands is theoretically possible - it is simply to indicate that under the present arrangements for water administration on major irrigation schemes this potential is not realisable. The issue of water in maha, for instance, is commonly extended to suit the slower cultivators so that any water saved by those who plant early does not contribute to an expanded cultivation in the minor monsoon (yala) season. Also, any advantage in the timing of harvest that could be achieved is inadequate to obtain price premia so that there is no perceived private advantage in early cultivation. Similarly, the issue of water for a yala season is not normally commenced until harvest of the preceding maha crop is complete. It is (as Carr, 1975, points out) chiefly on rainfed lands that the timing advantage of tractors comes into play, the crop being planted as near to the start of the rains as possible. This is not potentially a net advantage in all rainfed cultivation, however, since traditional slash and burn techniques permit the early preparation and planting of small acreages (generally not exceeding 5 acres/farm) of rainfed crops. In these cases the use of fire as a

[1] Insofar as it is statistically significant, since the confidence limits (±1 standard error) appropriate to the labour profile are much wider in the case of sub-areas (where the number of observations is approximately 20) than for locations as a whole.

[2] There are many plots at the tail ends of Uda Walawe, for instance, which have no expectation of irrigation water at all.

[3] These are, after all, at varying distances from roads within the location and do not lend themselves to rapid visual assessment.

tool permits land to be cleared prior to the rains, and the only tillage consists of making planting holes for the crop. Perhaps the advantage to tractors in timing of cultivation on rainfed lands arises in those areas which combine flat topography, large holdings and a population density which causes the breakdown[1] of traditional slash and burn techniques into short cycle chena, where the re-growth of vegetative cover will be inadequate to permit a good 'burn' within short fallow cycles. If, in addition, soil conditions are such that animal draught cannot be used to prepare seedbeds and obtain adequate weed control before the onset of the main monsoon, the use of tractors appears particularly attractive.[2] The mechanisation of tillage in areas such as these appears to have improved the timing of cultivation in, for instance, the large rainfed paddy farms in the Eastern Province described by Carr (1975), and in the rainfed paddy lands on the borders of Padaviya in our own samples. Obstacles to its introduction continue to exist, however, in those very few areas of the Sinhala Dry Zone where population pressures are high but paddy forms only a small component of the crop-mix. In Hambantota District, for instance, cotton and a variety of coarse-grain and leguminous crops are grown under short-cycle chena and under rotations within settled farming,[3] but physical barriers to mechanisation are imposed by the numerous tree stumps and rocks which it has not been necessary to clear under slash and burn. If the necessary investment for adequate land clearing is to be forthcoming, farmers must be able to expect high and reliable future income streams. The prices of non-paddy smallholder crops have, however, been notoriously unreliable, chiefly because of vacillations in food import policy.[4] In such an uncertain economic environment it is hardly surprising that investment in land clearing has not occurred. Once pricing policies have been devised which make the production environment more stable, a form of improved technology - be it mechanised or chemically based[5] may be more widely adopted.

5. Annual cropping intensity

Linked with our initial proposition on the timing of cultivation is the hypothesis that earlier and more rapid tilling under mechanisation

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[1] Effectively, this combination of criteria restricts the areas in question to the Dry Zone.

[2] Soil conditions in Jaffna District have permitted animal drawn ploughing, which has now been substituted with no apparent timing advantage by tractors. Incomes from farming have also been high, since rainfall is widely supplemented by lift irrigation from the limestone aquifers unique to this area. In the remainder of the Dry Zone, soils have generally been too hard at the end of the long dry season to allow animal powered ploughing, so that any tractorisation would substitute for hand cultivation.

[3] Farrington (1979).

[4] Gooneratne et al (1980); Wijayaratna (1981).

[5] e.g. one of the alternative advanced technologies, such as the precisely timed application of accurately measured herbicide sprays essential to the zero tillage, minimal tillage, cover-crop and strip cropping techniques under investigation by the IITA/Sri Lanka Programme (IITA/Sri Lanka (1980); Wijewardena (1980)). (See also Chapter 6.3 below).

systems permits a higher annual use intensity of land. This postulate is examined for both irrigated and rainfed land. With the former, rigidities in the timing of irrigation water issues may, as we indicated above, prevent full realisation of the potential of tractors for early cultivation and for obtaining the maximum use intensity from land.

However, it remains possible to postulate that their higher specific power output may permit tillage prior to irrigation issues in yala, and thus increase the chances of successful paddy cropping in areas where irrigation supply is marginally adequate.

Data presented in Tables 3.4.1 and 3.4.2 indicate an overall annual cropping intensity on operated irrigated lowland of 132% for the sub-sample of owners for whom farm records were kept, and of 128% for non-owners. These figures are substantially lower than the national average, which fluctuates around 150%.[1] This is almost entirely attributable to the absence of yala cropping at Padaviya, with its resultant downward bias on the overall figures.

The overall difference between owners and non-owners for this land category appears, however, negligible. Any improvement in lowland cropping intensity that the owner sample might show over non-owners may be attributable not to the fact that they own draught power, but to the favourable positions they occupy within irrigation command areas relative to the cross-section of non-owners. There were, for instance, none who had allotted lands in the areas of inadequate water supply at the tail end of the study locations. When operated non-irrigated land is included, owners (132%) appear to cultivate substantially more intensively than non-owners (123%), lending some support to our hypothesis that it is principally in the cultivation of non-irrigated lands that the higher power output of tractors will be translated into increased land use intensity.[2]

Within the owner sample for each location and for both land types, there is a slight tendency for 4wt owners to achieve higher cropping intensities than 2wt or buffalo owners. These differences are masked when data are aggregated across locations. They are small relative to the standard errors involved, and it would require much larger samples than those available here to establish whether they are significant.

For non-owners, there is a strong tendency for cropping intensity to be higher in the upper reaches of the locations than at the tail ends. This reflects both the inadequacy of irrigation supplies for paddy cultivation at the tail end of Uda Walawe, and the land-sharing arrangements under the bethma system at Kaudulla in yala 1980, with

[1] Department of Census and Statistics, Statistical Pocketbook of Sri Lanka, 1980, p.55.

[2] A District-wide analysis of paddy cropping intensities and tractor densities between two years (1957-58 and 1969-70) indicated little change in cropping intensity in spite of large increases in tractor populations in some Districts (Carr, 1975, p.249).

its subsequent de facto ramifications.[1]

The search for evidence of higher paddy land use intensity can be extended to include an agronomic practice, namely transplanting, the yield benefits of which are debatable,[2] but which can be taken to represent a land-intensification (and water-saving) practice in so far as it reduces the time period over which the paddy crop occupies the main area of irrigated land.

The proportion of paddy land transplanted in Sri Lanka varies both spatially and temporally. It is rarely practised in the low country Wet Zone areas where individual households tend to be deficit paddy producers (Moore, 1980b) and farming is only one of their several economic enterprises. In the hill country Wet Zone, where the opportunity for alternative economic activities is limited, the commitment to farming appears to be stronger, and transplanting is correspondingly more widespread. The proportions of paddy land transplanted in these two areas vary little over time. It is in Dry Zone major irrigation, where it has been adopted partly as a practice introduced by settlers from their villages of origin, that the proportion of land transplanted varies substantially over time.[3] In order to establish the reasons for such variations, it is necessary first to examine the potential advantages and requirements of transplanting.

It offers the following advantages:

1) Where there is pressure on the cultivation calendar, it permits faster turn round between crops by permitting the first 15-20 days of plant growth to take place within a nursery, thus leaving the main paddy field free for other activities. As we noted above in our discussion of crop timing, however, water issues in major irrigation in Sri Lanka are administered to coincide with the bimodal rainfall

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[1] Under the 'bethma' cultivation in yala in 1980 at Kaudulla, the allotments at the top end of the scheme were the only ones irrigated. These were split into equal shares among all allottees. However this attempt to provide equal cultivation opportunities was nullified by the handing over of the allocated land by the tail enders to their top end counterparts on share cropping arrangements ('Vee poronduwa') after they had encountered numerous difficulties in cultivating at such long distances from their homes (e.g. the problem of bringing their draught animals to the fields each day since top enders frequently refused to allow the animals to be left in situ overnight. Some top enders also demanded exhorbitant rates for tilling they had done on the bethma land prior to its allocation).

[2] Grist (1975), summarises the arguments for and against transplanting and quoting evidence from Paul (1945) and Wickramasekera (1941) in Sri Lanka, somes to the conclusion that whilst transplanting gave a 30-40% yield advantage over broadcasting when 6-7 month varieties were commonly used. The introduction of non-lodging, heavy tillering $3\frac{1}{2}$-$4\frac{1}{2}$ month varieties has reduced this advantage substantially.

[3] cf. Division of Agricultural Economics and Statistics, Department of Agriculture, **Agricultural Statistical Information Vols. I & II**, , Peradeniya, 1980.

distribution, which permits 6 months for each cultivation season. With the widespread use of paddy varieties which mature in 3½-4 months, this leaves adequate margins for such inter-seasonal activities as clearing and tilling without the need for the 'breathing space' afforded by transplanting. Given, however, the fact that farmers in major irrigation schemes do not usually start land preparation until water has been issued from the tank, the universal adoption of transplanting would save some 15-20 days' water. As we note below (Tables 3.4.5-3.4.6), however, transplanting is adopted on a piecemeal basis within major schemes, and even within sub-areas of our study locations, so that irrigation water cannot be saved without very sensitive mechanisms to divert it to precisely where it is needed. Subsequent discussion[1] indicates that such mechanisms do not currently exist, nor are they likely to be widely introduced in the medium term, so that without the universal adoption of transplanting, irrigation water will continue to be diverted into drains by those whose (transplanted) crop has matured (and therefore no longer needs irrigation water) before the run-of-the-mill broadcast crop[2].

2) Transplanting permits more even spacing of the crop, which permits more regular absorption of solar energy and plant nutrients, and may in this way increase the yield potential of the crop, especially with the new improved (i.e. IRRI derived) varieties which have short erect leaves.

3) Paddy which is planted in rows which are regularly spaced in both directions can be weeded by improved hand tools, such as the rotary weeder, which may remove constraints imposed by weed competition on the achievement of full yield potential. This, however, is again inapplicable to Sri Lanka since the near universal system involves broadcasting or random transplanting with inundation (and, more recently, herbicides) as the chief means of weed control.

4) Where paddy land is prone to flash flooding in the early stages of crop growth, a transplanted crop is more likely to survive because of its deeper root penetration than is one which has recently been broadcast.[3] This appears to be an important consideration in favour of transplanting in many parts of the hill-country Wet Zone.

5) For the Dry Zone, however, perhaps the major consideration in favour of transplanting is that it permits paddy land to remain under water for the entire season - from the first tilling to a point shortly before harvest. This has two major benefits: first, it does not require as much sophistication in seed bed preparation (especially in levelling and draining the land) as does broadcasting; second, it assists the decomposition of weeds buried during tillage and prevents the re-emergence of non-aquatic weeds during crop growth. On the other hand, transplanting has specific requirements which may act as constraints to its wider adoption:
   a) it requires a regular supply of water to the nurseries prior to planting out. Even in areas outside major irrigation schemes, where part of the water generally available for land preparation can be diverted to nurseries, this should not present any particular difficulty, since water requirements are small enough to be met by manual transport from groundwater sources;
   b) transplanting requires an assured supply of water to keep the field in a flooded condition immediately prior to and after

[1] Chapter 6.

[2] On most major irrigation schemes, the density of Irrigation Department staff is so low, and the density of (functioning) water control structures so sparse, that it would be impossible to keep this currently wasted water within the canal system (Moore, 1980a).

[3] Broadcasting is currently the only alternative to transplanting. Various dibblers and seeders for mudland sowing of paddy have been under trial for many years but have not been widely adopted by farmers (Pillainayagam, 1978).

TABLE 3.4.5: NON-OWNER SAMPLE: PADDY ACREAGE TRANSPLANTED IN RELATION TO TOTAL PADDY ACREAGE BY LOCATION AND SUB-AREA WITHIN LOCATION (Maha season only).

	UDA WALAWE			KAUDULLA			PADAVIYA			ALL LOCATIONS		
	Total Paddy Acreage	Trans-planted Acreage	% Trans-planted	Total Paddy Acreage	Trans-planted Acreage	% Trans-planted	Total Paddy Acreage	Trans-planted Acreage	% Trans-planted	Total Paddy Acreage	Trans-planted Acreage	% Trans-planted
Top[1] Sample 1	51.00	0.00	0.0	47.50	42.80	90.1	55.20	8.98	16.3			
Sample 2	42.00	0.00	0.0	33.63	28.96	86.1	63.40	6.07	9.6			
Tail[2] Sample 3	10.44	0.00	0.0	43.32	0.00	0.00	59.40	22.11	37.2			
Sample 4	14.00	0.64	4.6	66.00	3.84	5.8	24.00	5.11	21.3			
All[3]	117.44	0.64	0.5	190.45	75.60	40.2	202.00	42.27	20.9	509.89	118.51	23.2

TABLE 3.4.6: OWNER SAMPLE: PADDY ACREAGE TRANSPLANTED IN RELATION TO TOTAL PADDY ACREAGE BY LOCATION AND POWER TYPE OWNED (Maha season only)

	UDA WALAWE			KAUDULLA			PADAVIYA			ALL LOCATIONS		
Those Owning:	Total Paddy Acreage	Trans-planted Acreage	% Trans-planted	Total Paddy Acreage	Trans-planted Acreage	% Trans-planted	Total Paddy Acreage	Trans-planted Acreage	% Trans-planted	Total Paddy Acreage	Trans-planted Acreage	% Trans-planted
4wt	47.50	4.50	9.5	96.71	89.00	92.0	163.98	61.50	37.5	308.19	155.00	50.3
2wt	51.75	10.50	20.3	117.78	82.00	69.6	126.96	49.50	39.0	296.49	142.00	47.9
Buffalo	31.92	2.50	7.8	84.15	72.65	86.3	75.40	13.88	18.4	191.47	89.03	46.5
All	131.17	17.50	13.3	298.64	243.65	81.6	366.34	124.88	34.1	796.15	386.03	48.5

Notes:
1. At Uda Walawe Samples 1 and 2 refer to the upper and lower ends of tract 4, at Kaudulla to the upper and lower ends of Tract 1 and at Padaviya to Tract 2 and to the upper end of Tract 6.
2. At Uda Walawe, Tracts 18 and 19 respective; at Kaudulla, Tract 8 and off-scheme villages below Tract 8, respectively; at Padaviya, Tract 12 and the lower end of Tract 6.
3. In view of the diverse composition of the 'top' and 'tail' categories, it was thought inappropriate to present more than an overall yield figure under the 'all locations' heading.

transplanting;

c) perhaps of most direct relevance to Dry Zone major irrigation, transplanting involves some commitment of capital in nursery establishment, and thereafter commits the farmer to a planting out deadline which he must be confident of fulfilling. If the availability of draught power for land preparation or of hired labour for transplanting itself, is uncertain the initial investment (in nursery establishment) may be lost. Additionally, the farmer must have sufficient ready cash available at the beginning of the season to pay the large gangs of hired labour necessary for timely completion of transplanting. These are frequently migrant (Chapter 2; Appendix 4.3) and so cannot be paid on the deferred crop-share basis occasionally adopted in payment for e.g. draught power.

We should, therefore, expect transplanting to be a relatively more common phenomenon among those who control their own draught power than those who have to resort to the hire markets.[1] At first sight this appears to be borne out by Tables 3.4.5-3.4.6, the overall proportion of the maha paddy crop transplanted by owners being 48.56 against 23.2% for non-owners, there being little difference within the owner sample by power type owned. An important consideration, however, appears to be the farmers' expectation of adequate and regular water supply. This is evident in the non-owners samples at Kaudulla, and less clearly at Padaviya, where the incidence of transplanting decreases with increasing distance from the irrigation headworks. Since none of the owner sample holds allotted lowland in the irregularly watered areas at the tail ends, but many non-owners do, some effort must be made to remove the differential impact of water availability on the adoption of transplanting between the two samples. This can most conveniently be done by comparing owners with non-owners located at the top ends of command areas. At Kaudulla, the location with the highest overall incidence of transplanting, this revised comparison would now reduce owners and non-owners to the same footing, whereas owners would remain more inclined to transplant at Uda Walawe and Padaviya.

We would conclude, therefore, that confidence in the availability of draught power and in the prompt regular and adequate supply of water are prerequisites to the adoption of transplanting in major irrigation. It is impossible to describe either of these as more important than the other. A priori reasoning and our own data (Tables 3.4.5.-3.4.6) suggest that both are necessary conditions for the successful adoption of transplanting. The empirical evidence suggests, however, that the added confidence in adequate timing of cultivation conferred by the ownership of draught power - particularly of tractors - as opposed to its hiring in is not a strong influence on the proportion of holdings transplanted.

3.5: Paddy Yields and Mechanisation

Our discussion above of the potential of mechanical power for intensification of land use (and its performance in this regard in Sri Lanka) has embraced some practices associated with mechanisation which have potential effects on paddy yields, and others which do not. Of those practices which might a priori be expected to influence paddy yields, only an improvement in

[1] Apart from their draught power, they also command sufficient wealth to permit immediate cash payments to hired labour (Chapter 5 below).

crop timing may be classified as a direct effect of mechanisation, and this, we have argued, appears in practice to have been negligible in major irrigation in the Dry Zone. Other practices not directly caused by mechanisation but perhaps induced by an increased confidence in the availability of farm power to which mechanisation may have contributed,[1] include a switch to improved varieties (again, negligible in the cases we have discussed) and a higher incidence of transplanting, of which there is some evidence. Other (agronomic) factors associated with tractor tillage which we have not discussed above but which may influence yields include deeper tillage and better weed control through 4wt ploughing. The body of experimental evidence on these issues has, however, been reviewed, (Farrington and Abeysekera, 1979), with the conclusion that the use of 4wt with nine-tine tillers, as is almost universal[2] in small farms, gives shallow penetration and leaves large clods of earth.[3] Both of these factors will, if anything, have adverse effects on yields.

In Tables 3.5.1-3.5.3 we examine the characteristics of paddy yields of owners and non-owners for the maha season only and for maha and yala seasons combined.[4] The effect of season appears to be negligible (Table 3.5.1) whilst non-owners' yala yields for those two locations where a yala crop was cultivated (Uda Walawe and Kaudulla) were lower than for maha, they were not significantly so. Yield differences between locations were significant for maha and for yala.

Within the owner sample, owners of tractors (of both types) generally achieve slightly higher yields than do buffalo owners, but not significantly so. There is no clear pattern of difference between owners of 2wt and 4wt, and even when tractor owners alone are compared with the non-owner sample, differences (of some 5 bushels/acre for maha and yala combined) remain non-significant.

Yield differences between owners and non-owners within location do not appear to follow a consistent pattern. Whilst the two seasons' mean yield of owners is slightly higher than that of non-owners at Uda Walawe, and significantly higher at Kaudulla, the owners' overall mean is substantially (but not significantly) lower at Padaviya. This latter case runs contrary

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[1] In Chapter 6, however, we argue that the introduction of 4wt is unlikely to have had strong effects on confidence in the availability of draught power. The effect may even have been negative, since the proportion of farmers controlling their own draught power is likely to have diminished as tractors have displaced buffalo - an argument advanced by Carr (1975, pp. 165 ff).

[2] See Appendix 3.6.

[3] Certain other yield enhancing factors, such as fertiliser application levels, are associated with mechanised farming without being caused by tractor use. In such cases, both tractorisation and the use of these inputs are attributable to a third factor, namely higher-than-average levels of income and wealth.

[4] These yields, lying broadly in the range 60-70 bu/ac, correspond with those more widely reported for major irrigation in the Dry Zone (e.g. ARTI, 1979a).

to the pattern at the other two locations. It can be explained largely by the inclusion of a sample of 4wt owners at Pulmoddai (outside the Padaviya command area) who obtained low yields (37.7 bu/ac) on the paddy land they cultivated under rainfed conditions. This is evident in Table 3.5.3 in which the 4wt owners' yield falls well below that of 2wt owners', by contrast with other locations. Since exclusion of the Pulmoddai sample would increase the overall mean yield for owners, the difference stated above between overall yields for owner and non-owner samples may have been underestimated. It does not, however, alter the fact that much of the yield difference can be accounted for by differences in opportunities for access to irrigation water, and not by any inherent advantages of mechanisation or of practices induced by mechanisation.

Our discussion so far of the factors affecting yields has inevitably been incomplete - indeed it would require a separate study in its own right to quantify and analyse all yield influencing parameters, embracing variations in micro climate, soil type, purity of line characteristics in paddy seed, quality and timing of nutrient availability, of weed competition, of solar energy and so on. One further factor can, however, easily be incorporated into the analysis at this stage, namely fertiliser application, and, since all paddy varieties used are highly responsive to application of NPK mixtures and of nitrogen alone, this appears likely to be a key factor in explaining yield variations.

Fertiliser application levels are presented alongside yield data in Tables 3.5.2-3.5.3. With pooled data over all locations, owners' use-level of fertilisers is some 60 lbs/ac. higher than that of non-owners' in maha (significant) and 35 lbs/ac. higher for the two seasons combined, (not significant). The same trend holds for individual locations, the differences being significant at Uda Walawe and Kaudulla (maha only) but not at Padaviya. For non-owners, there is a tendency for top end farmers to apply more than tail enders.

The fertiliser use patterns correspond broadly with yield trends, but there are exceptions in individual data cells, indicating that fertiliser use-levels, whilst an important explanatory variable in yield analysis, are by no means the only factor. For instance, at Padaviya, owners' fertiliser use-levels are slightly higher than those of non-owners', whilst their yield levels are lower. The differences are significant in neither case, and so may be spurious. On the other hand, insofar as the differences are real they may be accounted for in part by variations in the proportion of paddy land which is irrigated, particularly since the extensive holdings of some tractor owners embrace plots which rely partly or wholly on rainfall.[1]

In order to examine whether non-owners' yields correlated with variations in power type used, a breakdown of yields by power type and operation was made for both owners (Table 3.5.4) and non-owners (Table 3.5.5). Numbers of observations vary markedly from one location to another, and in

[1] Fertiliser use-levels are generally less than half the recommended levels (Appendix 7). There is, however, a substantial body of research which suggests that recommendations for chemical inputs derived from trials on experimental stations will be too high for peasant farming conditions (cf. Farrington, 1977).

TABLE 3.5.1: NON-OWNER SAMPLE: MEAN YIELD/ACRE BY SEASON

	UDA WALAWE			KAUDULLA			PADAVIYA			ALL LOCATIONS		
	Mean Bu/ac	S.E.	No. of Cases	Mean Bu/ac	S.E.	No. of Cases	Mean Bu/ac	S.E.	No. of Cases	Mean Bu/ac	S.E.	No. of Cases
MAHA	50.6	2.3	61	61.7	2.0	88	71.4	2.5	85	62.4	1.4	234
YALA	44.7	2.2	44	56.2	1.7	42	-	-	0	50.4	1.5	86

TABLE 3.5.2: NON-OWNER SAMPLE: PADDY YIELDS AND FERTILISER USE-LEVELS BY LOCATION WITHIN THE COMMAND AREA (Maha only)[1]

		UDA WALAWE					KAUDULLA				PADAVIYA				ALL LOCATIONS			
		Yield		No.of	Fertiliser Whole Sample		Yield		No.of	Fertiliser Whole Sample	Yield		No.of	Fertiliser Whole Sample	Yield		No.of	Fertiliser Whole Sample
		Bu/ac	S.E.	Cases	Lbs/ac	S.E.	Bu/ac	S.E.	Cases	Lbs S.E.	Bu/ac	S.E.	Cases	Lbs/ac S.E.	Bu/ac	S.E.	Cases	Lbs/ac S.E.
Top End[1]	Sample 1	53.9	3.9	21	59.8	10.9	69.4	4.8	23	163.2 24.5	82.8	3.4	21	65.5 16.3				
	Sample 2	56.2	3.7	20	137.4	13.9	57.1	3.7	16	114.8 28.2	56.3	3.7	22	192.5 89.1				
Tail End[2]	Sample 3	51.9	7.3	6	51.5	25.2	60.8	3.6	19	147.4 36.1	82.4	3.7	24	134.8 16.7				
	Sample 4	37.3	3.6	14	45.5	14.1	59.0	3.2	30	16.8 7.4	61.9	6.3	18	42.6 20.1				
All[3]		50.6	2.3	61	81.2	8.7	61.7	2.0	88	101.1 13.2	71.4	2.5	85	113.1 12.2	62.4	1.4	234	100.3 7.1

Notes:

1. At Uda Walawe Samples 1 and 2 refer to the upper and lower ends of Tract 4, at Kaudulla to the upper and lower ends of Tract 1 and at Padaviya to Tract 2 and to the upper end of Tract 6.
2. At Uda Walawe, Tracts 18 and 19 respectively; at Kaudulla, Tract 8 and off-scheme villages below Tract 8, respectively; at Padaviya, Tract 12 and the lower end of Tract 6.
3. In view of the diverse composition of the 'top' and 'tail' categories, it was thought inappropriate to present more than an overall yield figure under the 'all locations' heading.

TABLE 3.5.3: OWNER SAMPLE: PADDY YIELDS AND FERTILISER USE-LEVELS BY LOCATION AND BY POWER TYPE OWNED (Measured over pooled maha and yala data)

	UDA WALAWE					KAUDULLA					PADAVIYA					ALL LOCATIONS				
	Paddy Yield			Fertiliser		Paddy Yield			Fertiliser		Paddy Yield			Fertiliser		Paddy Yield			Fertiliser	
	Bu/ac	S.E.	No.of Cases	Lbs/ac	S.E.	Bu/ac	S.E.	No.of Cases	Lbs/ac	S.E.	Bu/ac	S.E.	No.of Cases	Lbs/ac	S.E.	Bu/ac	S.E.	No.of Cases	Lbs/ac	S.E.
4wt Owners Only	53.5	5.0	9	147.1	33.3	75.3	3.6	10	124.6	58.3	63.4	4.3	23	139.5	25.3	64.1	2.9	42	137.6	20.3
2wt Owners Only	49.1	2.6	18	148.1	20.2	75.6	5.3	15	261.6	29.9	69.0	4.1	20	158.3	33.1	64.0	2.8	53	184.1	18.0
Buffalo Owners Only	49.9	2.4	11	139.0	25.7	66.6	2.7	37	162.9	25.1	59.9	3.4	23	135.0	23.1	61.8	1.9	71	150.2	16.3
All	50.4	1.8	38	145.2	14.1	70.2	2.2	62	180.6	19.7	63.9	2.3	66	143.7	15.3	63.1	1.4	166	157.8	10.4

TABLE 3.5.4: OWNER SAMPLE: PER ACRE YIELDS OBTAINED BY FARMERS BY TYPE OF FARM POWER USED ON INDIVIDUAL OPERATIONS. (Mean for Maha and Yala seasons).

	UDA WALAWE			KAUDULLA			PADAVIYA			ALL LOCATIONS		
	Bu/acre		No. of	Bu/acre		No. of	Bu/acre		No. of	Bu/acre		No.of
	Mean	S.E.	Cases	Mean	S.E.	Cases	Mean	S.E.	Cases	Mean	S.E.	Cases
TILLING[1]												
by hand	-	-	0	-	-	0	46.7	0.0	1	46.7	0.0	1
by 4wt	-	-	0	65.7	5.7	2	68.8	3.7	22	68.6	3.4	24
by 2wt	49.3	2.9	17	69.1	7.0	10	64.4	4.5	19	59.9	2.9	46
by animal	50.0	2.3	18	67.7	2.6	45	62.8	4.0	18	66.3	2.2	63
LEVELLING												
by hand	52.0	3.0	6	50.0	0.0	1	71.5	1.8	3	57.6	3.5	10
by 4wt	-	-	0	68.0	0.0	1	59.2	4.1	13	59.8	3.9	14
by 2wt	50.8	4.4	9	73.0	4.5	12	63.7	7.5	6	63.8	3.5	27
by animal	-	-	0	68.4	2.5	50	68.6	3.8	29	68.4	2.1	79
THRESHING												
by hand	-	-	0	-	-	0	-	-	0	-	-	0
by 4wt	50.7	1.9	35	66.6	2.4	57	63.5	2.5	57	61.7	1.5	149
by animal	-	-	0	71.4	4.9	15	60.9	3.8	16	66.0	3.2	31
WINNOWING												
by hand	49.8	2.9	10	67.8	3.7	25	60.6	3.1	27	61.8	2.2	62
by 4wt	46.0	0.0	1	-	-	0	60.4	3.7	27	58.9	3.8	28
by 2wt	51.5	2.6	21	66.2	3.0	37	67.4	3.9	21	62.5	2.1	79
by machine	-	-	0	79.2	5.8	6	-	-	0	79.2	5.8	6

TABLE 3.5.5: NON-OWNER SAMPLE: PER ACRE YIELDS ACHIEVED BY FARMERS BY TYPE OF FARM POWER USED FOR INDIVIDUAL OPERATIONS

	UDA WALAWE			KAUDULLA			PADAVIYA			ALL LOCATIONS (Maha & Yala Combined)			ALL LOCATIONS (Maha Only)		
	Bu/Acre Mean	S.E.	No. of Cases	Bu/Acre Mean	S.E.	No. of Cases	Bu/Acre Mean	S.E.	No. of Cases	Bu/Acre Mean	S.E.	No. of Cases	Bu/Acre Mean	S.E.	No. of Cases
TILLING															
by hand	41.9	3.4	14	57.2	13.5	4	37.7	9.8	4	43.9	3.7	22	45.8	4.4	18
by 4wt	11.9	0.0	1	39.6	4.7	3	54.5	3.2	14	49.6	3.7	18	49.6	3.7	18
by 2wt	60.0	2.8	40	56.0	3.5	14	76.5	11.3	5	54.3	2.4	59	59.8	2.9	39
by animal	49.3	2.5	43				63.1	5.9	12	52.3	2.4	55	54.2	3.4	35
by animal				58.2	1.6	126	84.6	6.0	15	60.2	1.7	141	62.6	2.3	101
by animal							71.3	4.3	20	71.3	4.3	20	71.3	4.3	20
by animal + 4wt							65.6	6.2	17	65.6	6.2	17	65.6	6.2	17
LEVELLING															
by hand	44.9	2.8	22	62.4	8.8	11	55.7	6.3	8	51.7	3.2	41	57.3	5.1	22
by 4wt	-	-	0	48.6	0.0	1	-	-	0	48.6	0.0	1	48.6	0.0	1
by 2wt	52.5	2.7	36	54.2	4.5	6	71.0	0.0	1	53.2	2.4	43	59.4	2.9	24
by animal	24.0	0.0	1	57.4	1.4	130	74.1		66	62.8	1.4	197	64.0	1.7	159
THRESHING															
by hand	36.5	3.6	16	26.7	6.7	2	-	-	0	35.4	3.3	18	38.7	3.7	13
by 4wt	51.1	1.7	86	58.7	1.9	87	69.5	2.9	64	58.8	1.3	237	60.9	1.6	179
by animal	13.0	0.0	1	57.2	2.3	68	68.4	3.7	31	60.3	2.1	100	63.2	2.4	79
WINNOWING															
by hand	38.1	5.9	12	58.5	1.7	107	68.8	2.3	87	61.7	1.5	206	63.9	1.8	163
by 4wt	-	-	0	117.6	0.0	1	69.2	9.8	7	75.3	10.4	8	75.3	10.4	8
by 2wt	52.4	1.8	70	56.8	2.6	31	94.9	0.0	1	54.2	1.5	102	56.0	2.1	66
by machine	-	-	0	53.5	6.0	7	-	-	0	53.8	6.0	7	53.8	6.0	7

Notes: Operations as defined in Appendix 4.1.

view of the significant differences in yield levels between locations (see Tables 3.5.2-3.5.3), extreme caution must be used in interpreting the pooled data over all locations. At the same time, numbers of observations within locations are low for certain operation/power type cells, which again require caution in interpretation. Superimposed on these methodology-related problems is that of assigning causality: does the adoption of certain power types lead to low or high yields, or do yields act as some index of wealth, which determines the capacity to afford certain power types?

In spite of these difficulties, some trends can be detected:

- first, it seems clear that the use of human labour alone in any operation (with the exception of winnowing, and possibly, levelling) is correlated with low yields, (and small acreages - see Appendix 3.1) and almost certainly reflects low economic status and the inability to pay for anything other than manual labour.

- second, although the numbers of observations are low, the yields achieved by those using 4wt are significantly lower than the location-specific means, and this is not explained by low fertiliser use (Table 3.5.6). They are also significantly lower than for those who used 4wt for land preparation in the owner samples. We are at a loss to explain these phenomena, unless they are evidence of the validity of Carr's[1] hypothesis, namely that tractor owners tend to rush through land preparation on hire contracts, but complete the operation more carefully on their own fields.

- third, threshing by buffalo appears to be a practice adopted by smaller (Tables 3.3.3 and 3.3.4) though not lower-yielding farmers. This may reflect both their overall lower wealth and, conversely, some scale economies in the use of tractors for threshing, partly because the overheads in time and expense of getting a tractor to come to small holding will be higher per acre than for a large one,[2] partly also because operating efficiency may be higher[3] the larger the paddy heap to be threshed.

Farm power and crop production - Multivariate analysis

The attempt to explain variations in crop production by multivariate analysis of levels of inputs is beset by numerous problems of specification, estimation and the attribution of causality. Exhaustive discussion of these lies outside the scope of this study.[4] For present purposes perhaps the most important difficulty lies in the high degree of multicollinearity commonly observed among independent variables in farm level regression models of agricultural production. This is particularly so where crop acreage is included as an independent variable, since there are strong a priori grounds to expect total inputs of labour and fertiliser use to vary directly with acreage. Where multicollinearity is strong,[5] particular caution is necessary in interpreting both the significance levels and regression coefficients of the independent variables concerned.

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[1] Carr, M. N., 1975, p.237.

[2] They may even be larger per farm if the small farm is located far from a main road, or at the tail end of a main or distributory channel.

[3] Tractor 'down time' whilst waiting for labour to remove excess straw may, for instance, vary little between heap sizes.

[4] See Dillon, 1968, for a review.

[5] A correlation coefficient of greater than 0.50 between independent variables was interpreted as evidence of strong multicollinearity in the present context.

TABLE 3.5.6: NON-OWNER SAMPLE: PER ACRE LEVELS OF FERTILISER APPLIED BY FARMERS BY TYPE OF FARM POWER USED FOR INDIVIDUAL OPERATIONS

	ALL LOCATIONS - MAHA ONLY Fert/Ac(lbs) Mean	S.E.	No. of Cases	ALL LOCATIONS - MAHA & YALA COMBINED Fert/Ac(lbs) Mean	S.E.	No. of Cases
TILLING[1]						
by hand	25.0	10.1	18	94.9	37.9	22
by 4wt	138.6	38.4	18	138.6	38.4	18
by 2wt	92.0	12.8	39	114.6	16.3	59
by animal	97.4	13.8	35	103.7	9.6	55
by animal	85.4	11.6	101	125.2	11.8	141
by animal	131.4	26.3	20	131.4	26.3	20
by animal + 4wt	93.3	32.4	17	93.3	32.4	17
LEVELLING						
by hand	86.9	27.2	22	98.0	16.4	41
by 4wt	100.1	0.0	1	100.1	0.0	1
by 2wt	102.3	13.3	24	129.5	20.2	43
by animal	99.0	9.1	159	118.9	8.8	197
THRESHING						
by hand	44.9	14.7	13	163.0	61.3	18
by 4wt	104.1	8.5	179	117.2	8.3	237
by animal	69.6	10.6	79	96.9	12.5	100
WINNOWING						
by hand	97.3	9.2	163	125.3	9.9	206
by 4wt	130.2	58.3	8	130.2	58.3	8
by 2wt	96.7	10.0	66	103.4	7.2	102
by machine	80.8	52.7	7	100.8	52.7	7

Notes: 1. Operations defined in Appendix 4.1.

Simple linear models of the general type :

$$y = a + bx + b_1x_1 \ldots$$

were used in the attempt to explain, first, yields per acre and second, output per plot[1] of paddy. The linear models were chosen in preference to more complex quadratic and logarithmic equations on several grounds: first, the non-linear relationships which might be anticipated are principally between the dependent and those independent variables which exhibit economies of size in respect of acreage,[2] but specification of the most important of these in the present context - farm power - was by a 0 - 1 dummy variable not by some measure of time input, so that emergence of the impact of size economies in estimation is avoided. Second, the size range of plots under analysis is small, so that the scope for emergence of such non-linear relationships is in any case limited. Third, the multivariate analysis presented here relies on regression as an approximate means of accounting for observed variations in output, not as a precise or fully-specified predictive tool for planning future input/output relationships.

(i) Yields per acre

Per acre yields were regressed against per acre inputs of labour and fertiliser, against crop acreage and against two 0 - 1 dummy variables, the first representing animal and mechanised tilling, the second (for the non-owner sample only) poor and good supplies of irrigation water. Regression results are presented in Appendix 3.5.

On the whole explanatory power of these equations was low, particularly among the owner samples where a higher degree of approximation in measuring (especially) labour inputs and acreages was adopted. For the owner sample, Uda Walawe equation produced significant regression coefficients for labour and fertiliser inputs, though these two independent variables exhibited strong multicollinearity (R=0.94), so that the respective shares of explained variations in yield for which they appear to account may be inaccurate. For non-owners, acreage, fertiliser and water availability were significant at Uda Walawe, and acreage and water availability at Padaviya.

In both cases in which acreage was significant, the sign of the coefficient was negative, indicating reduced per acre yields with increasing acreage.[3] In only one case from both non-owner and owner samples was there a significant coefficient for farm power as an explanatory factor in yield variations: for Padaviya owners the use of 2wt or 4wt over buffalo in tilling was associated on average with an increase in yield.

(ii) Output per plot

An attempt for both owner and non-owner samples to explain variations in total output (as opposed to per acre yields) by variations in inputs[4] of

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[1] 'Plot' is equivalent to 'farm' in the majority of cases, but see Appendix 3.

[2] The most important independent variable in this category in the present context is undoubtedly farm power - since the operation of 4wt may be more efficient the larger the farm, although the high densities of small liyaddes even on larger paddy farms on major colonisation schemes may reduce the prospects of obtaining these advantages.

[3] This corresponds with findings of higher intensity of cultivation and per acre yields on small farms reported by e.g. Andarawewa (1965) and Wickremasekera (1980).

[4] On an overall, not per acre, basis.

the same independent variables set, proved more successful in terms of the proportion of explained variation. In most cases the value of R^2 fell between 0.5 and 0.75 and all regression equations produced at least two coefficients significantly different from zero. Multicollinearity was, however, widespread, high correlations existing most frequently between acreage and labour and acreage and fertiliser use. In no cases was farm power correlated strongly with any of the other independent variables, so that the results for that variable at least are unlikely to be influenced by multicollinearity.

In all cases, acreage was significantly correlated with output, as was water availability in two of the three cases in which it was included. Labour was significant in three of the six cases considered, and fertiliser use in two.

The coefficients for the draught power independent variable were significant in two of the six equations - for owners at Uda Walawe and Padaviya respectively. The sign of the coefficient was positive, indicating that the change from animal to mechanical power was associated with an increase in output.

As far as the general significance of mechanised power in explaining variations in output and per acre yields is concerned, our conclusion must be that it is insignificant in the majority of cases observed. Only among the owner samples does it contribute significantly to per acre yields (at Padaviya) and to total output (at Uda Walawe and Padaviya). Whilst the findings have a certain intuitive appeal, insofar as tractors can be expected to contribute more strongly to output and yields among those who own them than among those who merely hire their services, they may be spurious for two reasons: first, the measurement of farm inputs and output involved potentially a larger number of approximations and inaccuracies in the owner than in the non-owner samples; second, water availability proved to be a highly significant explanatory variable where it could be incorporated (i.e. among non-owners only). It could not be allowed for among the owner samples, yet the observed spatial distributions of draught power suggest that water availability is generally better for tractor owners than for buffalo owners. This suggests that the significant mechanisation dummy variable found for some of the owner samples may have been measuring not only differences in draught power, but, to a large extent also, variations in water availability. It would, therefore, be injudicious to attribute solely to mechanisation the yield and output effects observed in this part of the regression analysis.[1]

In summary, there are no strong *a priori* reasons to expect the use of tractors to *cause* higher yields. Indeed, for the South and South East Asian Region as a whole, there is "increasing evidence to suggest that tractor use does not result, in most cases, in increased output either through changes in yield per hectare or through changes in cropping intensity".[2] With the implements conventionally used in Sri Lanka, soil preparation is shallow and clod size large and in any case the most direct

[1] The need for caution is emphasised by the fact that, where water availability could be taken into account, the sign of the power coefficient was negative in 4 of the 5 cases in which power was included in the equations. In two of these cases, the negative coefficients became significant after slight re-specification of the labour variable (see Appendix 3.5).

[2] Barker (1977) p.5, citing Duff, 1976.

current means of weed control in land preparation is through the improvement in decomposition achieved by leaving paddy plots under standing water. There are thus no purely agronomic grounds to support the premise that 4wt lead to higher yields. The other possible direct effect of 4wt - through improved timing - has been demonstrated to be negligible. Whilst the data show, on the whole, a positive correlation between tractor ownership and yields, it would be erroneous to regard this as a causal relationship. Tractor owners operate paddy land on which higher applications of fertiliser are made, and which (with the exception of some paddy holdings at Padaviya) are located in the upper (and, therefore, better watered) ends of irrigation command areas. The adoption of transplanting is also relatively higher among owners than among non-owners. The weight of evidence thus suggests that it is these factors, and not the use or non-use of tractor draught per se, which influence yield levels.[1]

[1] For further discussion of the role of tractor in relation to water use efficiency and the timing of cultivation, see Chapter 6 and Appendix 5.

CHAPTER 4: MECHANISATION AND LABOUR

The attempt to place any employment effects of farm mechanisation into broader perspective is hampered by problems of methodology in conventional definitions of 'employed' and 'unemployed' and by the lack of current statistics.

The 1971 Census Data,[1] for instance, reported that 82% of the total labour force of 4,434,000 was employed, and that 49% of these were employed in agriculture, forestry, fishing and hunting. In addition to this number, it is likely that many thousands of those nominally employed in other activities also participate in agriculture, particularly in the Wet Zone, where part-time farming is common (ARTI, 1975). Furthermore, it seems unlikely that the application of Census definitions is sensitive enough to detect the contribution to livelihoods made by agriculture through the casual employment of (particularly) female and child labour. We should thus regard 49% of the active labour force as a minimum estimate of the employment generation of agriculture.

Until data from the 1981 Census become available, it will be difficult to assess the extent to which employment patterns have changed over recent years. A recent report (Central Bank, 1980), however, suggests that the level of unemployment has decline to "about 15%" - i.e. a rise in employment by three percentage points since 1971, but that employment creation, at an overall 278,035 for the three years 1978-80, is not proceeding rapidly enough to absorb the 125,000 new entrants per annum onto the labour market. This trend is particularly disturbing, since, as the Central Bank Report emphasises, the years following trade liberalisation in 1977 were likely to have offered particularly strong opportunities for employment generation. The slowing down of employment creation in the government sector - which had burgeoned under the previous governments in 1971-77 - is largely responsible for the overall reduction in the pace of employment creation. Whilst some (unrecorded) increase in employment may have taken place in the informal private commercial sector, at least some of the increased burden of absorbing new entrants to the labour market will fall on the agriculture sector.

Apart from the obvious question of whether patterns of growth and/or resource allocation in smallholder agriculture will permit absorption of its share of labour, there are the more complex issues of the aspirations of those currently unemployed. These form the focus of several studies[2] from which emerges the prospect that many (possibly half) of those unemployed in the rural sector are voluntarily unemployed, refusing to seek opportunities for manual work in agriculture and, relying on support from their families or friends, preferring to await the opportunity of white collar employment.

This issue raises questions of motivation, of the appropriateness of the education system, and so on, which lie outside the scope of the current study. The important point within our present concern with Dry Zone

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[1] The most recently available Census data incorporated into current official statistics (Department of Census and Statistics, 1980).

[2] Most notably by Srivastava and Selvaratnam, (1972), and by Moore (1979). The former was reviewed in some detail by Farrington & Abeysekera (op. cit.).

farming is that there is likely to be a reluctance on the part of adolescents in the rural community, particularly in wealthier families,[1] to take up employment in agriculture. Further, the most pressing requirement for jobs is likely to come from those living within the Dry Zone who do not operate sufficient land of their own to meet their consumption requirement, and so need to take on casual employment, and from those who migrate from Wet to Dry Zones in search of supplementary income earning opportunities.

Detailed statistics on the size and distribution of these two categories are not available. A survey by the Central Bank (1975), however, suggests that in the small farm sector, 55% of workers are self-employed agricultural operators, and 45% obtain at least part of their incomes by hiring out their labour. Of the latter, more than half (55%) own some land, whilst the remainder do not own land, but may have usufructory rights. A study by Perera and Gunawardena (1980), whilst not recognising explicitly the role of usufructory rights, indicates that over one third of the average monthly income across their sample of agricultural labour households was derived from work which did not involve the hiring out of their labour.[2] This statistic was derived from a sample of villages with resource endowments generally poorer than commonly found in large scale irrigation schemes.

For major irrigation, which forms the focus of our analysis, we might infer that, whilst the hiring out of labour is a common enough phenomenon, only a minority of those who hire out labour own no land, and many of these, whilst not owning land do have access rights. Since work outside agriculture also contributes to their incomes, it is only a small proportion of those working as hired labourers who must rely exclusively on agricultural employment as a source of income.

None of the above is intended to encourage underestimation of the role of agriculture in employment generation. Whilst smallholder farming does not have to bear the employment burden of, for instance, Bangladesh,[3] and Sri Lanka's resource pressures are not as extreme as those of several other countries in the Region, there remains the fact that the incidence of any displacement of hired labour by mechanisation will be entirely on the poor sections of the community, in an economy where alternative unskilled employment is difficult to find in the rural areas.

Whether the undoubted capacity of mechanisation for labour displacement would, in turn, generate unemployment is a question of key macro-economic importance. Quite apart from its well-known adverse social and political implications, there are likely to be economic costs (through food assistance and the payment of unemployment benefits etc. as well as through the loss of potentially productive capacity) associated with unemployment.

Our analysis of the impact of mechanisation on the labour market must proceed in two stages: it is first necessary to establish to what extent labour is displaced by mechanisation; we can then address the broader question of whether any such displacement is likely to lead to unemployment.

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[1] Since success in completing secondary education - the minimum acceptable for permanent white collar employment - correlates strongly with the socio-economic status of the student's family (Moore, 1979).

[2] It included, for instance, operation of agricultural land, petty trading, and the pursuit of local crafts.

[3] Gill (1981) Chapters 7-8.

4.1: Effects of Mechanisation on Labour Use in Farm Operations

The conventional notion in studies of mechanisation in underdeveloped countries (c.f. Binswanger, 1978) is that increased use of mechanical power will first reduce the employment of hired labour, leaving family labour use unchanged. Only with progressive increases in the degree of mechanisation will family labour inputs be affected.

The theoretical underpinning of this notion as follows:

On small farms with a very limited range of crop and/or livestock enterprises, the pattern of agricultural activity, dictated broadly by climatic considerations, will be highly seasonal. For much of the year the farm family alone will be able to provide the necessary labour inputs. For those operations which require large labour inputs, however, and are highly time specific, additional labour will have to be hired in from outside the farm, generally involving diversion of part of the hiring family's effort away from immediately productive activities and towards the recruitment and supervision of labour, the provision of meals, the raising of cash for wage payments, and so on. The wage levels demanded may, in any case, appear high to the farm family. When reduced to an hourly basis they may exceed the opportunity cost of a large part of the family labour force, without necessarily generating a higher average product per hour than family labour would. This is particularly so if rigidities such as the need to cook meals, to look after children, to attend school, and so on allow only a part-time labour input from several family members and would prevent them from realising their full potential opportunity cost on the labour market.

The total cost of hiring labour may therefore be high relative to that of using family labour, and certainly will be perceived as high by the farm family. The pressure will be to generate innovations to relieve labour peaks such as these, examples of which, in the Sri Lankan context, are the use of (first) animal draught, and (subsequently) tractor power for land preparation and threshing. When such innovations are introduced, it is likely to be more economic to reduce the input of hired labour than that of family labour.

A recent review of labour-use data from a large volume of published and unpublished reports on Dry Zone Farming,[1] has, however, raised doubts about the applicability of these theoretical considerations[2] to Sri Lanka. As a starting point the review draws on empirical findings that most of the decline in overall labour input will be in land preparation, accounting for a reduction of some 6-10 man-days/acre. It goes on to note that conflict of opinion exists between the 'hired labour displacement' hypothesis of Carr, and the notion of Yudelman et al that additional hired labour may be necessary, particularly where[3] (as is common) tractor drivers have to be engaged along with the tractor.

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[1] Fieldson (1981). See also Fieldson and Farrington (1980).

[2] By Carr (1975) and Yudelman et al (1971) among others.

[3] Fieldson also notes that the large difference in size of paddy holding between tractor and buffalo users (4.8 acres versus 2.9 acres) in Yudelman's sample may have exaggerated the hired labour requirement of tractor users, since per acre hired labour inputs will in any case be larger with increases in holding size as family labour resources are spread more thinly over the available acreage (Wickramasekera, 1980).

From his analysis of reports providing data for 12 locations in the Dry Zone, Fieldson concludes that there is an overall difference of some 10 man-days/acre in labour input between farms displaying high levels of mechanisation on the one hand, and those with low/medium mechanisation on the other. The main component of this difference was land preparation, accounting for 7 man-days/acre with a shift from buffalo to 4wt tilling. Further, Fieldson found that the input of hired labour varied little with increasing degrees of mechanisation, whilst that of family labour decreased markedly from 11 man-days/acre in the low tractor-use group, through 9 days in the medium to 5 man-days/acre for the high tractor-use group, figures which were unlikely to be influenced by the small variation in paddy farm size among the three groups.

That mechanisation directly displaces labour from farming operations is by now beyond dispute. There is also broad agreement on the quantities of labour displaced in Sri Lanka from individual operations. The following analysis of data is intended to resolve two remaining questions: the first concerns the incidence of displacement on hired and family labour respectively; the second, whether any changes in the structure of the hired labour market have occurred as a consequence of mechanisation. The analysis is necessarily complex; it is divided into two parts: first, 'hypothetical' situations, in which only manual, animal or tractor power is assumed to be used for all relevant operations, are compared in their impact on total, family and hired labour use. Second, greater realism is introduced by comparing the labour effects of the varying observed levels of mechanisation which lie between these hypothetical extremes, and which are influenced by such other forces as farm size and draught power ownership status.

1. Hypothetical stages of mechanisation

In Tables 4.1.1 and 4.1.2 we trace for non-owners and owners respectively the differences in labour input associated with varying hypothetical degrees of mechanisation in the main operations. Sample sizes are adequate to permit firm conclusions for all operation x power type classifications for the non-owner sample, though for the owners they are smaller, particularly for manual tilling. Bearing in mind the differences in units of measurement (man-hours against man-days) between the two samples, and the unreliability of the 'manual' category in the owner sample, the two data sets bear close comparison at a conversion of 8 hours per day.[1] Thus, a farm on which all operations are performed manually would use 197 hours/acre/season more than one on which they are performed entirely by buffalo, the main difference (117 hours) arising in labour use for tilling. A progression from the use of buffalo to that of 2wt involves a further reduction of 93 hours (7.8 days), of which some two-thirds are in tilling. These figures correspond closely with Fieldson's estimates of 12 days overall and 7 days in tilling.

Of the overall difference of 275 hours/acre associated with completely manual labour at one end of the technology spectrum,[2] and the use of 4wt

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[1] This is recognised as a crude conversion coefficient. The length of working day is likely to vary by operation and by the age and sex of worker (Farrington, 1975). It is, however, considered adequate for present purposes.

[2] These 'stages' in the technology spectrum are presented for illustrative purposes only. It is recognised that dynamic factors need to be taken into account if technological change is to be fully conceptualised (see Table 4.1.1, Note 1).

TABLE 4.1.1: NON-OWNER SAMPLE: DIFFERENCES IN LABOUR INPUTS IN IRRIGATED PADDY CULTIVATION (MAN HRS/AC)[1] BY OPERATION AND BY TYPE OF POWER HIRED IN (Pooled data for maha and yala across all locations)

Type of change in farm power hired / Operation	Labour Type	From Manual	To Buffalo	From Buffalo	To 2wt	From 2wt	To 4wt	From Manual	To 4wt	From Buffalo	To 4wt	From Manual	To 2wt
Tilling	±all	-117		-70		-3		-190		-73		-187	
	±family	-147		-33		-8		-188		-41		-180	
	±hired	+30		-37		+5		-2		-32		-7	
Levelling	±all	-12		-8		nd		nd		nd		-20	
	±family	-11		-3		nd		nd		nd		-14	
	±hired	-1		-5		nd		nd		nd		-6	
Threshing	±all	-68		na		-17		-85		-17		na	
	±family	-32		na		-19		-51		-19		na	
	±hired	-36		na		+2		-34		+2		na	
Winnowing	±all	na		-15		+5		0		na		na	
	±family	na		-19		-1		-5		na		na	
	±hired	na		+4		+6		+5		na		na	
All	±all	-197		-93		-15		-275		-90		-207	
	±family	-190		-55		-28		-239		-60		-194	
	±hired	-7		-38		+13		-36		-30		-13	

Notes: 1. The assumptions widely used in Sri Lanka for conversion of the labour time of woman and child workers into man-hours (e.g. ARTI, 1979) were regarded as excessively crude, and the present study, drawing on the findings of Farrington (1975) applied a set of conversion coefficients disaggregated by labour type and by operation. Whilst work study data were not available to assist in their computation, the authors drew upon current information on relative wage rates and on the trends indicated by Farrington (1975) to arrive at a more comprehensive and sensitive set of coefficients than those conventionally used.

2. The types of change in degree of mechanisation indicated here are given for illustrative purposes only. It is recognised that the overall dynamic impact of changes in technology would not be completely analysed without consideration of inter alia:
   i) the impact of a change in technology in one operation on labour inputs for subsequent operations;
   ii) the impact of technology change on cultivated acreages, yields, the crop mix, cropping intensity etc. and, in turn, their impact on labour use.
   The reader is referred to Appendix 3.2 for an illustration of i) and the concluding section of Chapter 3 for ii).
   Furthermore, very few farms actually use the same power type through all operations.

na = not applicable, i.e. the operation is not commonly performed by the power type in question.

nd = no data or insufficient number of observations.

SOURCE: Calculated from Appendix 4.1.

TABLE 4.1.2: OWNER SAMPLE: DIFFERENCES IN LABOUR INPUTS (MAN-DAYS/AC) IN IRRIGATED PADDY CULTIVATION BY OPERATION AND BY TYPE OF POWER USED (Pooled data over all locations and for maha/yala combined)

Type of change in farm power used		From Manual	To Buffalo	From To 2wt	From To 4wt	From Manual	To 4wt	From Buffalo	To 4wt	From Manual	To 2wt
Operation	Labour Type										
Tilling	+-all	nd		-5.5	-1.6	nd		-7.1		nd	
	+-family	nd		-5.9	-1.7	nd		-7.6		nd	
	+-hired	nd		+0.4	+0.1	nd		+0.5		nd	
Levelling	+-all	nd		-2.3	-0.9	nd		-3.2		nd	
	+-family	nd		-1.4	-0.3	nd		-1.7		nd	
	+-hired	nd		-0.9	-0.6	nd		-1.5		nd	
Threshing	+-all	nd		na	nd	nd		-2.1		nd	
	+-family	nd		na	nd	nd		-1.6		nd	
	+-hired	nd		na	nd	nd		-0.5		nd	
Winnowing	+-all	nd		na	-1.5	nd		na		nd	
	+-family	nd		na	-0.7	nd		na		nd	
	+-hired	nd		na	-0.8	nd		na		nd	
All	+-all	nd		-7.8	-2.5	nd		-12.4		nd	
	+-family	nd		-7.3	-2.0	nd		-10.9		nd	
	+-hired	nd		-0.5	-0.5	nd		-1.5		nd	

Notes: as for Table 4.1.1.
Note that these figures reflect the power types used by the owner sample, a more appropriate criterion for operation-wise analysis than the type owned (Chapter 3, introductory paragraphs).

SOURCE: Calculated from Appendix 4.1.

wherever possible at the other, 65%[1] is associated with the first stage in this technological sequence, i.e. with the difference between hand labour and buffalo use. Only 30% and 5% respectively are associated with the shifts from buffalo to 2wt and from 2wt to 4wt. Contrary, therefore, to the commonly held views for Sri Lanka (e.g. Carr, 1975) and for the Region as a whole (Binswanger, 1978) there is little difference between 4wt and 2wt in the overall volume of labour used. In a broader perspective, the most signigicant technology step as far as reductions in labour use are concerned is that from manual labour to animal draught. It is necessary, however, to place these differences into a reasoned historical context: a large-scale shift from manual to animal power occurred several centuries ago in Sri Lanka (Siriweera, 1981) at a time when population pressures were low and the consequences of labour displacement negligible among an agrarian society of owner-cultivators. In present circumstances, it is only the poorer members of the farming community (frequently located at the tail ends of command areas) who have to rely exclusively on manual labour. The technological shift of major current consequence is that between animal and tractor draught, and even though the total labour displacement it involves is much lower than that of the manual-to-animal progression, its timing coincides in

[1] Since the operation x power type cells are not identical for each of the stages described, the totals under 'All' in Tables 4.1.1 and 4.1.2 cannot be summed. However, a percentage based on the broad values of the data has been given.

many societies with the increasing emergence of landless labour and low ratios of job opportunities to available workforce. Its consequence might therefore be disproportionately severe in relation to the volume of displacement.

2. Variation in labour input for observed levels of mechanisation

Whilst the hypothetical farming situations illustrated in Tables 4.1.1-4.1.2 illustrate the aggregate employment impact of varying levels of draught technology applied across all operations, they do not necessarily reflect the actual technology mix and labour-use patterns of owners and non-owners. These will diverge from the hypothetical figures since both owners and non-owners vary their use of power to suit the operation in question,[1] not always relying on the owned power source. Varying adoption levels of practices specific to operations outside those discussed in Tables 4.1.1-4.1.2 will also influence overall labour use.[2] The size of farm can also be expected to influence both the overall per acre labour input and the proportion of hired labour used.[3] In Tables 4.1.3-4.1.4 we therefore present the overall per acre labour inputs of owners and non-owners respectively (for paddy only) disaggregated into family and hired labour.

For the owner sample, overall per acre labour inputs decline from buffalo through 2wt to 4wt owners, corresponding with increases in both the degree of mechanisation and the size of operated paddy holding (Tables 3.4.1-3.4.2). Within this declining trend however the input of hired labour actually increases from 30.1 days/acre on buffalo farms to 33.6 on 2wt farms and 38.6 days/acre on 4wt farms. This appears, at first sight, to conflict with the slight downward trend in hired labour use associated with increases in the (hypothetical) levels of mechanisation illustrated in Tables 4.1.1-4.1.2. It can, however, be explained partly by the larger overall paddy farms operated by tractor owners and by their higher adoption of transplanting, an operation which relies heavily on the employment of hired labour gangs.

Greater conceptual clarity, and more precision in policy prescriptions, where the question of employment is more important than that of displacement, may be achieved in the interpretation of these data if we distinguish between on the one hand, a farming system in which tractors are already well established, and in which we seek to establish the labour effects of an expansion

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for instance, all buffalo owners at Kaudulla and Uda Walawe, and 50% of those at Padaviya, hired in 4wt for threshing but not for any other field operation.

[2] In Tables 3.4.5-3.4.6, for instance, we demonstrated that the owner sample had adopted transplanting, a highly labour-intensive practice, more widely than non-owners.

[3] Fieldson (1981) for instance, reviewing several published and unpublished studies of Dry Zone smallholder family, finds a significantly positive correlation between cultivated paddy acreage and per acre hired labour inputs, and a weakly negative correlation between acreage and per acre family labour input, but no correlation between acreage and overall per acre labour inputs. Wickramasekera (1980) however, does find a consistent negative relationship between acreage and overall per acre labour inputs. Clearly, empirical findings can be expected to vary according to the range of farm sizes observed. In both studies, however, the proportion of hird labour rose with increasing farm size.

TABLE 4.1.3: NON-OWNER SAMPLE: INPUTS FOR FAMILY AND HIRED LABOUR IN PADDY PRODUCTION BY LOCATION AND SUB-AREAS WITHIN LOCATION (Man-hours/acre - means over two seasons, maha and yala)

	Sub-Area	Labour Type	UDA WALAWE Mean	S.E.	KAUDULLA Mean	S.E.	PADAVIYA Mean	S.E.	ALL LOCATIONS Mean	S.E.
Sample 1[1]	Top	All	464.1	31.8	602.4	2[illegible].9	720.9	3[illegible].6		
		Family	470.4	26.5	421.3	24.5	483.4	38.6		
		Hired	193.8	9.5	181.1	20.7	237.6	20.5		
		% Hired	44.0		29.8		34.6			
Sample 2		All	627.7	21.7	649.6	42.7	528.7	57.5		
		Family	347.8	17.8	462.9	45.4	343.7	60.5		
		Hired	279.8	12.6	186.7	30.3	185.0	16.2		
		% Hired	45.1		30.5		39.3			
Sample 3		All	549.1	62.8	522.4	39.3	545.3	49.5		
		Family	287.3	46.7	280.6	39.4	273.5	23.4		
		Hired	261.8	67.2	241.9	44.3	271.8	39.4		
		% Hired	43.5		44.1		46.7			
Sample 4	Tail	All	964.8	128.7	469.9	34.7	698.0	81.5		
		Family	765.5	135.8	373.8	33.6	404.5	53.8		
		Hired	199.3	44.4	96.0	18.0	293.5	45.5		
		% Hired	23.5		20.3		40.2			
	ALL	All	625.1	32.0	565.6	17.7	616.7	29.5	598.7	15.0
		Family	391.1	32.1	395.2	17.5	371.3	23.8	387.5	14.2
		Hired	234.0	12.2	170.5	13.6	245.5	16.4	211.2	8.3
		% Hired	40.6		29.8		40.4		38.2	

Note: 1. Samples 1-4 are as detailed in Table 3.4.3.

TABLE 4.1.4: OWNER SAMPLE: INPUTS OF FAMILY AND HIRED LABOUR IN PADDY PRODUCTION BY LOCATION AND POWER TYPE OWNED (Man-day/acre - means over two seasons, maha and yala).

Owners of	Labour Type	UDA WALAWE Mean	S.E.	KAUDULLA Mean	S.E.	PADAVIYA Mean	S.E.	ALL LOCATIONS Mean	S.E.
4wt	All	43.0	6.3	64.1	7.2	48.1	4.1	50.8	3.3
	Family	16.5	3.2	12.0	2.2	10.5	2.5	12.2	1.6
	Hired	26.5	4.5	52.0	8.4	37.5	3.2	38.6	3.1
	% Hired	60.7		77.7		80.7		75.7	
2wt	All	41.9	4.3	66.3	6.7	61.8	7.0	56.1	3.8
	Family	20.5	2.9	17.3	3.3	27.8	7.5	22.5	3.2
	Hired	21.4	3.2	49.0	7.1	33.9	5.1	33.6	3.3
	% Hired	51.6		71.6		60.8		60.5	
Buffalo	All	52.1	6.7	76.1	3.5	64.1	5.6	68.5	2.9
	Family	19.9	2.7	39.7	2.9	45.1	4.7	38.4	2.4
	Hired	32.2	7.8	36.4	3.0	19.0	3.1	30.1	2.4
	% Hired	54.6		47.3		30.0		42.8	
All	All							60.0	2.0
	Family							26.6	1.7
	Hired							33.3	1.6
	% Hired							56.8	

in the volume of tractor hire, and, on the other, the labour impact of increasing the stock of tractors, with a consequent increase in the ratio of owners to non-owners.

In the former, the more widespread hiring of tractors in paddy farming is unlikely to lead to increases in acreages, cropping intensities or yields (Chapter 3). Nor are farmers hiring in tractors likely to become more involved in non-farm economic activity (Table 4.2.1.). Tractors will thus substitute directly for animal draught in an otherwise static situation, and the labour effects will be restricted to the farming operations directly affected. Thus, we can anticipate that the use of 4wt instead of buffalo would displace some 12 labour days per acre in tilling and threshing, of which some two thirds would be family labour. Similarly, the use of 2wt instead of buffalo for tilling would displace some 8½ days/acre, of which half would be family labour (Table 4.1.1). Under the current fairly buoyant demand conditions for unskilled labour in the economy it seems reasonable to assume that displaced hired labour will be able to earn alternative livelihoods, if not in the immediate vicinity of major irrigation schemes, then by migration to areas of high activity in construction and transport in the Wet Zone. For as long as the opportunity cost of hired labour is greater than zero, which seems a reasonable assumption in current economic conditions, the release of hired labour for alternative employment should be counted as a benefit, not as a cost.[1] The displacement of family labour, however, may represent a more substantial burden to the national economy in spite of the private benefits it may bring, insofar as a substantial part of the withdrawal (especially that of women and children) is likely to be into activities which are non-economic (e.g. leisure) or, at best, only peripheral to the functioning of the economic system (e.g. more orderly running of the domestic houshold). Even for family adult males, there is no indication from our data that those hiring in tractors are more heavily involved in off-farm economic activities than those hiring in buffalo. Additionally, family labour is likely to be more heavily committed (through its holding of land) to a specific locality than hired labour might be, and so less mobile in search of temporary employment. Under present conditions we should, therefore, regard the displacement of family labour as a more serious cost to the national economy, both because of its greater volume and because of the reduced prospects of its taking up alternative economic activity.

Dimensions of a different order are involved in the analysis of the labour impact of a spread in the ownership of tractors. In addition to the technology factor, differences in farm size - those of 4wt owners being some 50% larger than buffalo owners' farms - will reduce the share of family in total labour inputs,[2] and account to some extent for less labour intensive cultivation on tractor owning farms.[3]

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[1] See also the exploratory cost-benefit analysis conducted in Chapter 6.

[2] Assuming that the expansion of farm size associated with 4wt ownership in the past can be extrapolated to future ownership (see Tables 3.4.1-3.4.2).

[3] The difference overall of some 18 days/acre between 4wt and buffalo farms is larger than the displacement of buffalo by tractors in tilling and threshing alone would suggest (Tables 4.1.1-4.1.2). Yet, tractor ownership is associated with slightly higher yields and higher adoption levels of such labour intensive practices as transplanting. At least part of the unexplained difference may be accounted for by reductions in labour-use rates achievable through the larger scale of operation of 4wt farms.

Within this context, the apparently greater per acre use of hired labour by tractor owners could be spurious for two reasons:

First, cross-sectional comparisons of this type do not account for possible changes in labour use patterns over time. There is no reason to suppose that, prior to the advent of tractors, buffalo owners constituted a homogeneous population, of which present day buffalo owners are broadly representative. What appears much more likely is that the sub-group of buffalo owners who eventually came to own tractors was particularly progressive, well-educated, favourably endowed or any combination of these. It seems plausible that, even as buffalo owners, their share of family labour in total labour input was low to allow time for various other directly or indirectly productive pursuits, or for leisure. Cross-sectional comparisons between present labour use patterns on tractor and buffalo owning farms may therefore exaggerate the reduction in family labour use and correspondingly overestimate any hired labour effects attributed to the change in technology.

Second, even if due allowance for these time-series factors were to have little impact on the observed similarity between per acre hired labour use on 4wt and buffalo farms any attempt to attribute neutral hired labour employment effects to increased 4wt ownership would be, at best, highly specific to time and place. It is only where tractor farms can expand, by bringing hitherto uncultivated land under the plough, to a size substantially larger than farms operated under other technologies that this will be the case.

In major irrigation in Sri Lanka, however, the bulk of new 4wt owners would rely on finding any additional (acquirable) land within the limits of what is already cultivated by non-owners, so that the use of labour on any newly-tractorised farms must be set against the loss in employment opportunities on those farms switching from buffalo to tractor operations. As we have seen (Table 4.1.4) such a switch involves the loss of 69 labour days for every 51 days gained if the current scale of operation of 4wt and buffalo farms is to continue for the future. We must therefore conclude that, purely from the viewpoint of labour effects in farming operations, a spread in the ownership of tractors is likely to lead to a greater volume of labour displacement (some 18 days/acre per season)than is an expansion of tractor hire (12 days/acre/season).

The incidence of displacement between family and hired labour is particularly important in its implications for employment and income distribution. As indicated above, the apparent tendency among power owners for the per acre employment of hired labour to increase with increasing mechanisation may be partly spurious because of, first, the effects of larger farm size among 4wt owners on the family/hired labour mis and, secondly, because of inadequate allowances for any substitution of hired for family labour by current 4wt owners long before 4wt were introduced. It is unlikely, however, that these provisos would account for more than a small part of the tendency of mechanisation to displace not hired but family labour. This seems particularly so, since a similar displacement pattern is evident among non-owners, both

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'Strictly, the requirement is that the land should at present be uncultivated and should not be required for cultivation by more labour intensive methods than 4wt technology during the period of reference.

in the hypothetical and observed data.[1] The mechanisms of displacement which may account for this pattern are examined in detail in Appendix 4.2. Briefly, there is evidence that both a voluntary withdrawal of and some technologically-based displacement of family labour are involved.

Finally, the time-profile of hired labour requirements is examined in Figures 4.1.1-4.1.3. These merit the proviso that they are constructed from observations on two consecutive seasons at individual locations, so that the labour input patterns may be influenced by such time and location-specific factors as rainfall distribution.[2] Certain generalisations may, however, be made:

- At all locations the input of family labour rarely exceeds 40 hours per farm per week. Only in exceptionally busy periods does it rise to 70-80 hours/week (i.e. during harvesting at Kaudulla and Padaviya).)
- The use of hired labour is highly time-specific, twin peaks corresponding with land preparation/planting and harvesting/threshing. the employment opportunities for casual (frequently migrant) labour are thus restricted to 4-6 weeks at each of these critical peaks.
- Although there are differences of degree, at all locations the peak activity is harvesting/threshing when labour activity is both at its most intense and remains so over the longest number of weeks. During these operations family labour appears able to provide only half (sometimes, as at Kaudulla and Uda Walawe, less than half) of the necessary total labour input.

We might conclude that in spite of substantial mechanisation of land preparation and threshing at these locations the demand for hired labour remains highly specific to land preparation/planting and harvesting/threshing. The demand for hired labour at other times remains uniformly low, so that the prospects of providing longer term semi-permanent employment contracts with a greater degree of job security than is possible under season-specific requirements do not appear to have improved with mechanisation.

4.1.1: Summary

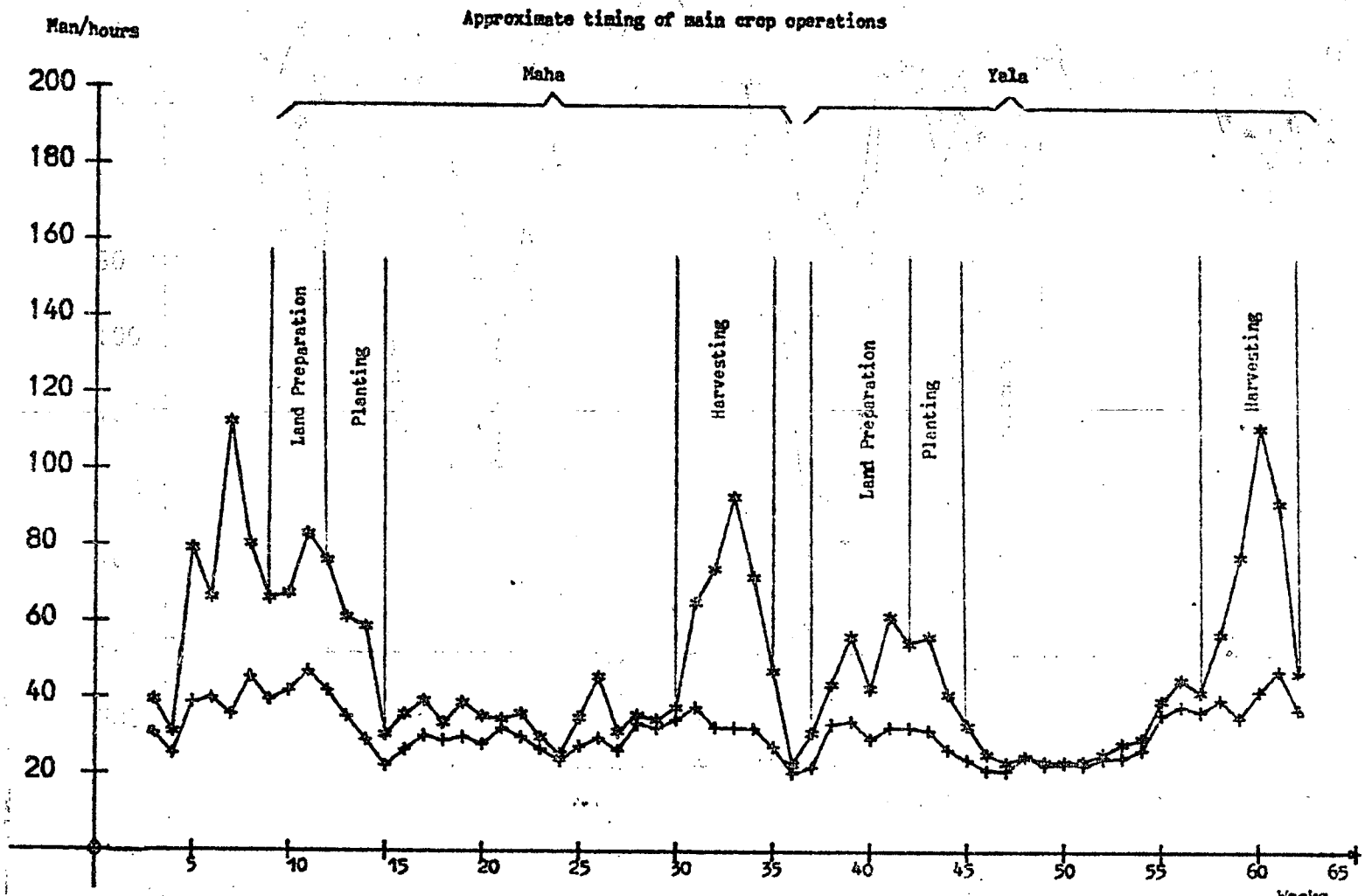
To summarise the complex effects of mechanisation on labour use in agricultural operations, the data indicate:

- An overall level of displacement of some 12 days per acre in total between the use of buffaloes and that of tractors for land preparation and threshing. In historical terms this is a much smaller displacement than that involved in the progression from manual cultivation to animal draught. However, since most paddy allotments in major irrigation currently use animals, this is the technology step of greatest relevance for policy purposes, and in current circumstances of increasing population pressure, is likely to be more severe in its impact per unit of labour displaced than were displacements several centuries ago under the manual-to-animal progression.

[1] The findings of a recent study conducted by the National Council of Applied Economic Research (India) also indicate that the bulk of labour displacement involves family, not hired, labour, a phenomenon explained as in this study (Appendix 4.2) by the withdrawal of female and child labour from farming activities (NCAER, 1980).

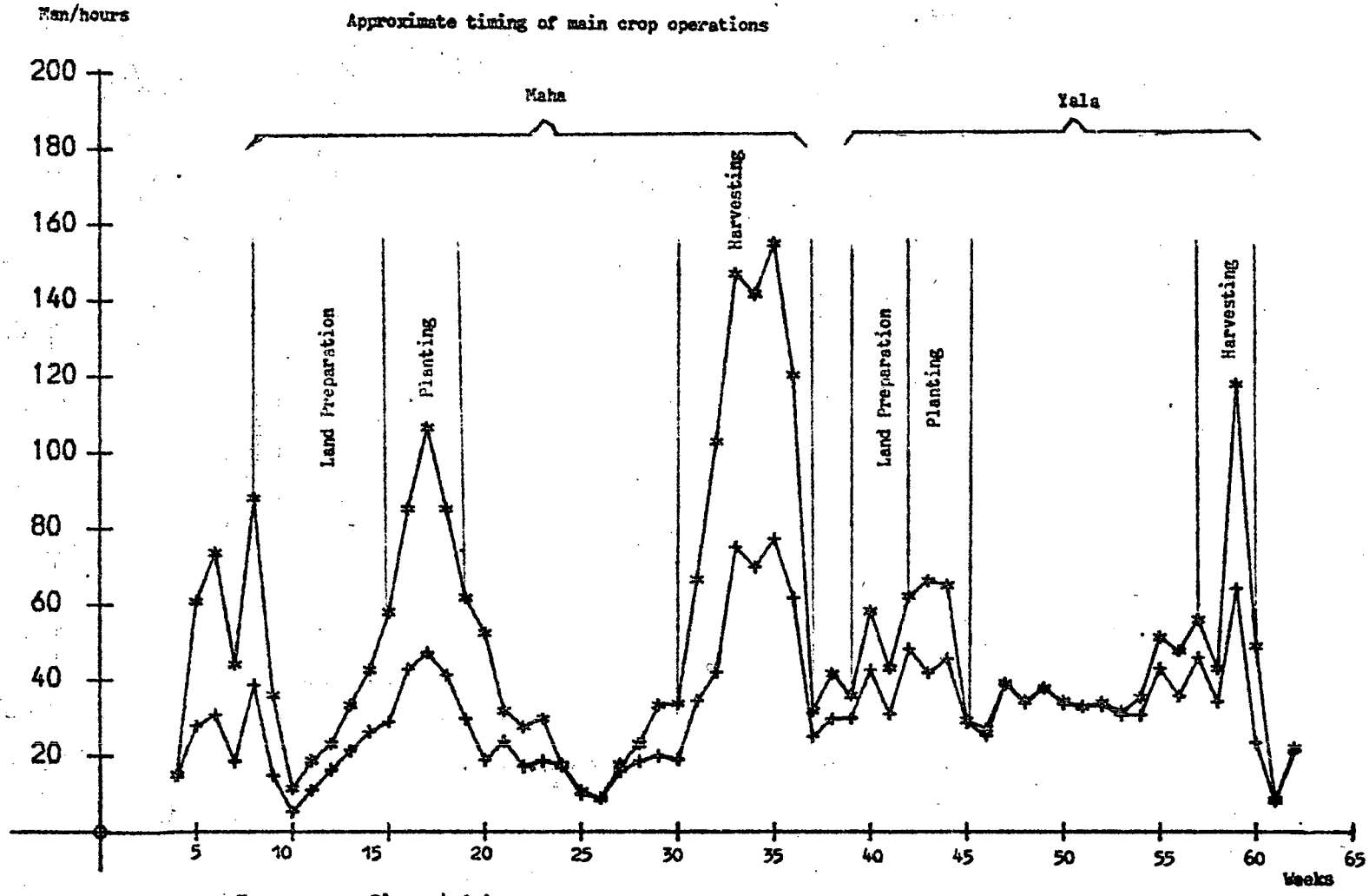
[2] At Kaudulla, for instance, heavy rain in weeks 10-12 delayed field work and caused land preparation to be spread over a longer period than would normally be the case (Figure 4.1.2).

FIGURE 4.1.1: NON-OWNER SAMPLE - UDA WALAWE. Inputs of family and hired labour per farm by week (paddy only)
Mean size of paddy farm = 2.01 acres (maha)
1.30 acres (yala)



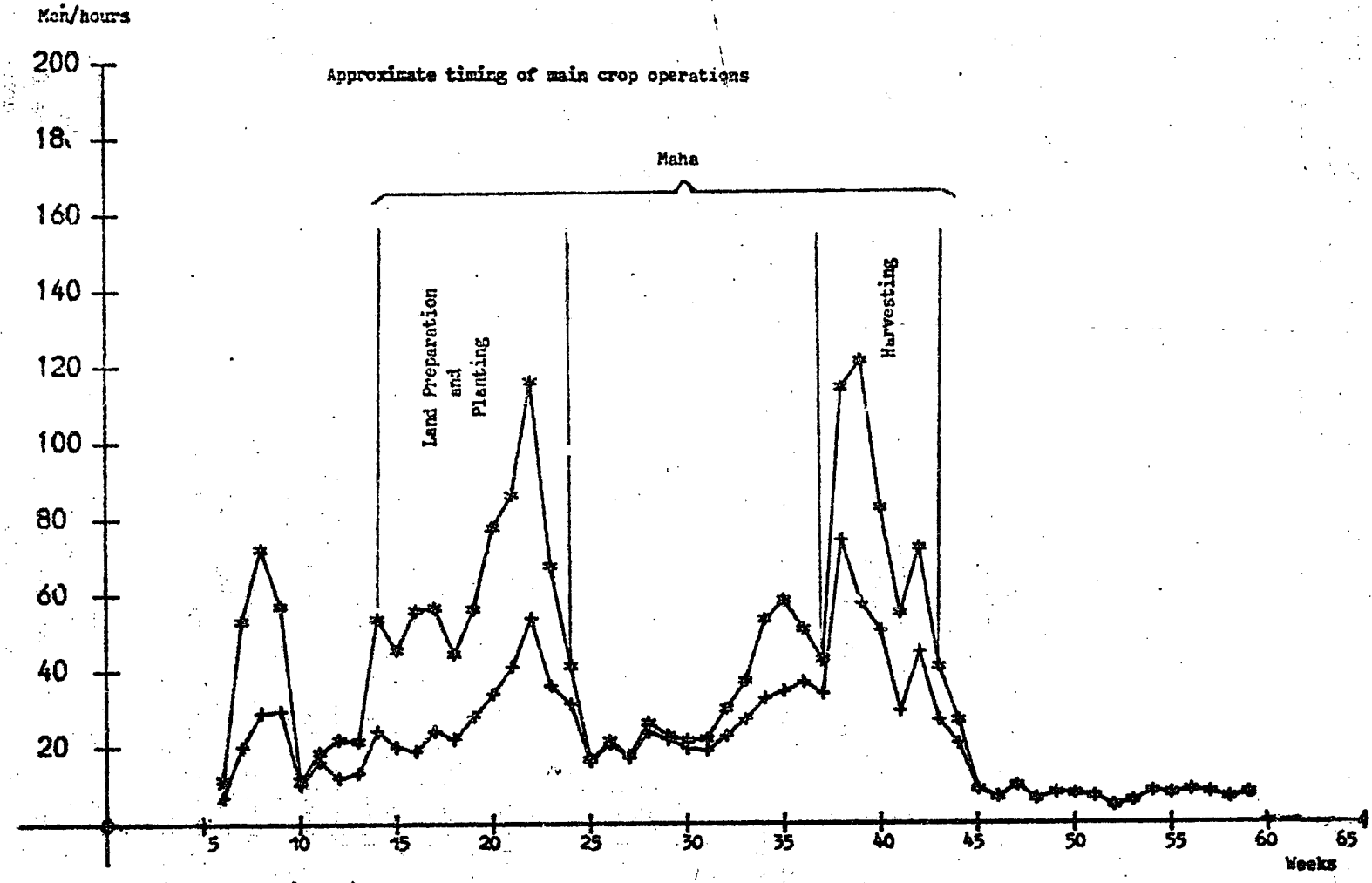
Notes: Week 1 = Week beginning 7.8.79.
• – • = Total labour input
+ – + = Family labour input

FIGURE 4.1.2: NON-OWNER SAMPLE - KAUDULLA. Inputs of family and hired labour per farm by week (paddy only)
Mean size of paddy farm = 2.47 acres (maha)
0.64 acres (yala)



Notes as per Figure 4.1.1.

FIGURE 4.1.3: NON-OWNER SAMPLE - PADAVIYA. Inputs of family and hired labour per farm by week (paddy only)
Mean size of paddy farm = 2.52 acres (maha)
0.00 acres (yala)



Notes as per Figure 4.1.1.

- The bulk of displacement falls on family, not on hired labour. Although there are reasons for believing that the displacement of family labour is overestimated in the owner sample data, the fact that similar levels of displacement are found among non-owners suggests that the finding is broadly valid. Much of the displacement among non-owners is attributable to the need to hire drivers with mechanised power, whereas the hirer's family provided part of the labour necessary for driving draught animals. Whilst the extent to which non-owners can compensate by increasing the proportion of family labour in operations peripheral to threshing is limited by the increased 'peakiness' of threshing by tractor, the same constraint does not apply to land preparation, yet little effort appears to have been made to substitute family for hired labour in operations peripheral to land preparation, presumably because of the drudgery involved.

- Whilst the time requirements for indirectly productive work such as arranging tractor hire may have increased with mechanisation, the weight of evidence is that non-owners accept increased leisure[1], especially for women and children, as a spin off of tractor hire. There is no evidence that they engage in additional farming activities or in directly productive non-farming enterprises.

- The withdrawal by 4wt owners of female and child labour is strong, and constitutes a substantial part of the difference in per acre family labour inputs between 4wt and buffalo owners.[2]

- Both the higher level of technology and larger farm sizes among 4wt owners account for a reduced share of family labour in total per acre labour inputs.

- Whilst the observed differences in employment patterns between 4wt and buffalo owners indicate for policy purposes the likely labour effects of marginal increases in mechanisation, they may underestimate the time-series impact of mechanisation on the displacement of hired labour.

- In major colonisation schemes, the potential for expanding the size of farm is largely limited to the prospects of (illicitly) buying or renting in land currently cultivated by others. If current buffalo owning farms are therefore to tractorise and to reach the mean farm size attained by 4wt owners, there will be a net loss of work opportunities of some 18 days per acre per season. If they are to remain at the same size as current buffalo owning farms, the loss in employment will be approximately 13 days. An increase in the hire of 4wt at the expense of buffalo use will result in the loss of some 11 days/acre/season for land preparation and threshing. The indications are that both an increase in 4wt hire and in 4wt ownership will cause displacement mainly of family labour. The latter, however, through increasing the holding sizes of new 4wt owners at the expense of other allottees on major irrigation schemes, is likely to be more severe in its social impact through reducing the effective holding sizes of those not owning tractors.

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[1] Barr (1975 p. 260) indicates that non-owners hiring in tractors are less likely to use the displaced family labour productively than are owners. The great majority of owners and non-owners felt that some family labour had been released through tractorisation but only 32% of non-owners against 50% of 4wt owners spent the time mainly in economic activities (20% and 22% respectively for 2wt).

[2] See Appendix 4.2.

There remain to be summarised the various elements of change in the structure of the market for hired labour which have emerged at different points in the above discussion.

First, the use of hired[1] tractors instead of hired draught animals at land preparation removes one of the functions (i.e. the driving of draught animals) traditionally performed in part by the hirer's family. The overall role of family vis-a-vis hired labour is therefore reduced, and the scope for maintaining family labour inputs by substituting it for hired labour in operations peripheral to land preparation does not appear to have been exploited. Within the hired labour component at both land preparation and threshing, there has emerged a division between the employment of a skilled and highly paid worker with some security of job tenure (i.e. the tractor driver)[2] and that of the bulk of lower paid casual workers whose duties traditionally included the driving of buffalo and the various 'tidying up' operations peripheral to the main ploughing. Whilst the emergence of this more skilled category of worker in the farm economy is significant, the proportion of hired labour time for which it accounts is low[3] and is unlikely to increase.

Of greater significance are the new patterns of labour hiring dictated by the mechanisation of threshing. The higher performance of tractors has resulted in the compression of this operation from the 4 days required by buffalo into less than one day by tractors for a 3 acre paddy allotment. Apart from reducing the scope for family labour use, this compression requires the hiring of a large gang of labourers, each for the one day period, to keep the tractor supplied with threshing material. Whilst the farmer hiring in buffalo for threshing is unlikely to have had difficulty in hiring the necessary two or three labourers for 4 days, the logistics of arranging for a larger number of labourers to be present on one day only are more complex. Consequently, the task of recruiting threshing labour to work with the tractor has been largely taken over by the tractor operator, who can offer employment for a number of weeks, taking the labour from one holding to another. The tractor operator thus offers a threshing 'package' to the hirer, which includes tractor, labour and, frequently also transport and marketing services.[4]

Clearly, the services of tractors in ploughing and threshing, and the structural changes they imply, must be regarded as acceptable by hirers at prevailing farm gate prices, or they would simply not be adopted. That they would have been as widely adopted without the extensive subsidies on tractorisation since 1950 seems unlikely. Their currently widespread use draws attention to shifts in the balance of power in rural areas which are not necessarily reflected in farm gate prices but are of wider social

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[1] Emphasis on the hire market is justified by the fact that over two-thirds of all tractor time is spent in custom work (Part 1 Report, p.65).

[2] A tractor driver will typically have secure employment for several months during land preparation and threshing, and will typically earn Rs.25-30 per day against Rs.17.50 per day for casual labour.

[3] Less than 10% in ploughing and threshing.

[4] The emergence of both semi-skilled employment in tractor driving, and of the control of labour gangs by tractor owners are likely to have reduced the employment opportunities for migrant vis-a-vis local unskilled labour. The role of migrant labour at the study locations varies more by location than by level of technology, however (Appendix 4.3), and although precise estimates of the impact of these trends on employment opportunities for hired labour cannot be given, the indications are that they will be slight. The potentially serious income distribution implications of displacing migrant labour (Crooks and Ranbanda, 1981) are therefore unlikely to be realised.

concern. In particular, the farmer's control over the timing and quality of execution of agricultural operations has diminished with the advent of tractor hire services. Apart from the reduction in direct participation through his physical labour, there arise the problems of delay in obtaining a hired tractor and of poor quality of work once it is obtained.[1] Additionally, the tractor operator, and no longer the farmer, has become a focus of employment opportunity during the threshing period. These several forces point to an increasing concentration of economic power, in both agricultural production and in the control of the labour market, into the hands of tractor owners and away from those farmers who rely on hiring in tractor services.

4.2: Effects of Mechanisation on Labour Use in Non-farming Activities

As far as the pursuit of non-farming enterprises is concerned, Table 4.2.1 indicates a strong tendency for 4wt owners to be more heavily involved in off-farm activities than other owners at all locations, though as is discussed below, only a part of this is likely to be directly attributable to the tractors themselves. In terms of the number of enterprises, 2wt owners rank a close second, with buffalo owners and non-owners trailing. The proportion of 4wt owners engaged in such (full time) activities exceeds that of non-owners by a factor of five.

The employment capacity of non-farm enterprises such as these cannot however be estimated from a simple count of the type presented in Table 4.2.1. The need for hired labour can be expected to vary by the type of enterprise, by its individual size and by the incidence of multiple enterprises operated by a single family. In Table 4.2.2 we therefore present the expenditure by ownership category and location on hired labour on a per annum basis. Clearly, 4wt owners are the most significant employers overall, but their non-farm labour costs vary from a mere Rs.55 p.a. at Kaudulla to Rs.2,646 p.a. at Padaviya. This difference is partly accounted for by the fact that a high proportion of Kaudulla owners are engaged in non-farm enterprises which do not involve further job creation - i.e. employment as white collar and blue collar workers (Table 4.2.1). Additionally, those off-farm enterprises with employment potential at Kaudulla appear to be particularly small (Appendix 5.2) with consequent minimal employment creation. At all locations, non-owners did not need to hire labour for the off-farm enterprises in which they were engaged.

The overall mean wage for unskilled labour varied among locations and by time of season from Rs.11.14 (Uda Walawe), through Rs.15.65 (Padaviya) to Rs.18.60 (Kaudulla). If we assume, as seems likely, that labour engaged by owners might incorporate an element of the semi-skilled (in e.g. managing stores, paddy mills and so on) it would be appropriate to apply a wage rate at the upper end of this range in attempting to estimate the number of labour days generated. Using Rs.17.50/day, we estimate that 4wt owners overall generate 83.3 labour days, as against 37.3 for 2wt and 18.6 for buffalo owners (Table 4.2.2).

Much, however, depends on the extent to which the non-farm activities and employment generated by tractor owners represent net additions to the

[1] These problems are discussed at length by Carr (1975) p.237 ff.

TABLE 4.2.1: THE INCIDENCE OF NON-FARMING ENTERPRISES[1] AMONG THE SAMPLES

(i) The Distribution of Non-farming Enterprises among Farm Power Owners by Power Type Owned and Location:

Number of owners and per cent for the ownership category engaged in the following enterprises

Those Owning	Type of Enterprise: Retail Store		Paddy Grinding Mill		White Collar Employee		Blue Collar Employee		Transport/ Construction Contractor		Other		All	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
UDA WALAWE														
4wt	6	30	0	0	2	10	0	0	4	20	6	30	11	55
2wt	2	8	3	12	4	15	4	15	0	0	2	8	13	50
Buffalo	2	11	0	0	2	11	2	11	0	0	1	5	5	26
KAUDULLA														
4wt	4	24	1	6	5	29	2	12	1	6	0	0	11	65
2wt	2	9	2	9	6	27	0	0	0	0	0	0	12	55
Buffalo	1	4	0	0	0	0	3	12	0	0	0	0	5	19
PADAVIYA														
4wt	10	43	5	22	4	17	0	0	3	13	0	0	17	74
2wt	4	17	0	0	4	17	7	30	1	4	0	0	14	61
Buffalo	1	5	0	0	0	0	7	35	0	0	0	0	7	35
ALL LOCATIONS														
4wt	20	30	6	10	11	18	2	3	8	13	6	10	39	65
2wt	8	11	5	7	14	20	11	5	1	0	2	3	39	55
Buffalo	4	6	0	0	2	3	12	20	0	0	1	0	17	26

(ii) Summary of Non-farming Enterprises of Non-owners[2]

All Non-Owners	15	7	1	0	4	2	10	4	0	0	1	0	31	13

Notes: 1. This summary includes only the full time enterprises. A variety of casual occupations (petty trading and working as manual labour) found chiefly among the non-owner sample are not included above.

2. Because some owners pursued multiple enterprises the totals in columns 1-6 do not necessarily sum to this total.

TABLE 4.2.2: MEAN ANNUAL EXPENDITURE BY OWNERS AND NON-OWNERS ON LABOUR FOR NON-FARM ENTERPRISES, BY TYPE OF POWER OWNED AND LOCATION

Owners of:	Uda Walawe	Kaudulla	Padaviya	All Locations
	Rs/Owner	Rs/Owner	Rs/Owner	Rs/Owner
4wt	629 (35.9)[1]	55 (3.1)	2,648 (151.3)	1,458 (83.3)
2wt	406 (23.2)	34 (1.9)	1,174 (67.1)	653 (37.3)
Buffalo	318 (18.2)	0 (0.0)	493 (28.2)	326 (18.6)
Non-Owners	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

Note: 1. Corresponding number of labour days at Rs.17.50 per day (see text).

level of economic activity in the areas in question which would not have been undertaken by buffalo owners. The breakdown of activities recorded in Table 4.2.1 does not indicate any which cannot, in principle, be undertaken by owners of draught animals. It is arguable, however, that tractorisation has permitted quantitative expansion and qualitative improvements in activities which would not have been introduced at all - or at best much more slowly - under animal draught systems. These include the development of transport contracts for building materials (e.g. in the Padaviya tank rehabilitation), for the transport of semi-industrial materials (e.g. paddy straw to the paper mills at Uda Walawe), the more rapid extraction of crops at the end of the season, reducing the risk of spoilage by inter-monsoon showers.

On balance, the contribution to incomes and employment in non-farm enterprises solely attributable to tractors seems likely to be positive, though more strongly so in areas with some urban and industrial infrastructure (e.g. Uda Walawe), than in those with very little. In the absence of data on the levels of these activities that might have existed under animal draught alone, it is impossible to quantify precisely the contribution of tractors; it will, in any event, vary over time and place. An intuitive estimate based on familiarity with tractor operations in the locations studied is that 4wt used primarily in agriculture contributes Rs.6,000 annually to income generation in non-farm enterprises, whereas a 4wt not used in agriculture contributes Rs.24,000 annually. These figures are used in the attempt to estimate overall costs and benefits of mechanisation in Chapter 6.

What emerges most clearly is that there is enormous unused potential for tractors in the rural areas to increase their contribution to income generation in non-farming activities: much tractor capacity and labour is unused in periods of low agricultural activity, and if only crop processing activities and other industries that are not site specific could be spatially dispersed, the benefits to tractorisation could be substantially higher. Unused capacity in tractor and labour markets certainly favour the allocation of high priority to such dispersal.

4.3: Employment in Activities Directly Related to the Power Source

Further to our discussion above of the impact of tractorisation - either through expanded hiring or ownership - on employment both in agriculture and in non-agricultural enterprises, there remain to be analysed the effects of substituting tractors for buffalo on the labour use patterns specific to the driving and maintenance of the respective power sources.[1]

Throughout the discussion below, we distinguish between two practices in the maintenance and use of buffalo. One method - perhaps more traditional for the Dry Zone - involves the highly concentrated ownership of large buffalo herds which are frequently pooled for grazing in the scrub jungles on the peripheries of major irrigation schemes, and are commonly employed in trampling ('mudding') the soil without the use of implements (as, for instance, at Uda Walawe). The second, observed at few locations in the Dry

[1] The time spent on driving the power types was included in the analysis of farm operations for buffalo (above). For tractors the time spent in agricultural operations was recorded in the same way: for non-agricultural operations data are obtained from the analysis of the tractor use time and are included in our discussion below.

TABLE 4.3.1: THE LABOUR DISPLACEMENT EFFECTS OF SUBSTITUTING ONE TRACTOR FOR BUFFALO UNDER TWO ANIMAL MANAGEMENT SYSTEMS

Tractor Type[2]	Operation Type	Labour Type[1]: SYSTEM A Family	SYSTEM A Hired	SYSTEM A All	SYSTEM B Family	SYSTEM B Hired	SYSTEM B All
4wt	**Farming**						
	Rate of labour displacement (days/ac)[3]	7.5	3.8	11.3	9.0	4.6	13.6
	Annual displacement (days)	225.0	114.0	339.0	270.0	138.0	408.0
	Herding						
	Rate of displacement (days/pair p.a.)	0.0	7.7	7.7	0.0	11.8	11.8
	Annual displacement (total days p.a.)[4]	-7.8	53.5	45.7	-9.9	111.9	102.0
	Feeding						
	Rate of displacement (days/pair p.a.)	59.0	0.0	59.0	0.0	0.0	0.0
	Annual displacement (total days p.a.)	590.0	0.0	590.0	0.0	0.0	0.0
	TOTAL DISPLACEMENT (DAYS/P.A.)[5]	807.2 (955.1)	167.5 (24.8)	974.7 (979.9)	260.1 (219.2)	249.9 (258.2)	510.0 (477.4)
2wt	**Farming**						
	Rate of labour displacement (days/ac)	4.1	4.7	8.8	6.4	7.3	13.7
	Annual displacement (days)	55.4	63.5	118.9	86.4	98.6	185.0
	Herding						
	Rate of displacement (days/pair p.a.)	0.0	7.7	7.7	0.0	11.8	11.8
	Annual displacement (total days/p.a.)	-12.7	34.7	22.0	-14.3	82.6	68.3
	Feeding						
	Rate of displacement (days/pair p.a.)	59.0	0.0	59.0	0.0	0.0	0.0
	Annual displacement (total days p.a.)	265.5	0.0	265.5	0.0	0.0	0.0
	TOTAL DISPLACEMENT (DAYS/P.A.)	308.2 (408.9)	98.2 (2.9)	406.4 (411.8)	72.1 (33.6)	181.2 (200.5	253.3 (234.1)

Notes:
1. Systems A and B refer respectively to the tethering, feeding and use of ploughs with small individual herds, and the open grazing of large herds used without implements.
2. The analysis of tractor and buffalo work rates in Table 3.2.1, although, for the reasons discussed, showing excessively low work rates, indicates a rate of substitution of one 4wt for 10 and 12 buffalo pairs under Systems A and B respectively, whilst one 2wt substitutes for 4.5 and 7 pairs respectively.
3. From Table 4.1.3. Calculation of the annual rate of displacement from farming rests on the additional assumption (derived from the data) that 4wt prepare 30 acres p.a. and 2wt 13.5 acres p.a.
4. Equivalent to the annual displacement from herding/pair multiplied by the displaced number of pairs, from which is subtracted the labour time necessary for tractor driving in non-agricultural operations (disaggregated by labour type).
5. The first row of totals relates to the labour displacement impact of obtaining the equivalent of one tractor's annual agricultural work by an increase in the volume of tractor hire activity, with no corresponding increase in the tractor stock and no change in other production parameters. The total in parentheses relate to the effect of increasing the tractor stock by one unit with the consequent increase in farm size of the farm which has bought the additional tractor, and lower overall labour use (Table 4.1.4).

Zone - most notably in the Polonnaruwa tank complex - appears to have been brought over by settlers from the Wet Zone, and involves the tethering and feeding of small individual herds of buffalo for much of the year, and their use with ploughs.[1] The main policy options in any future support of animal draught will inevitably draw on the major elements of one or the other of these two systems.

Returning to our discussion of the separate impact of an expansion in tractor hire from the existing fleet, as opposed to that of an expansion in tractor ownership, and bearing in mind the practical limits which are likely to face the former of these options, we can estimate the effects on labour use in agriculture and in the maintenance of the power source (Table 4.3.1).

The labour displacement effect of expanding the hire market sufficiently to obtain additional tractor time equivalent to the annual agricultural work of a single 4wt reduces employment by almost 1,000 days p.a. overall under intensive buffalo management (System A) and by roughly half this amount under extensive herd management (B). For one 2wt, the displacement effect is approximately half that of a 4wt. Under intensive buffalo management, the bulk of displacement falls on family labour, in view of its heavy commitment in feeding the tethered animals. Even in the extensive buffalo system, less than half the displacement affects hired labour.

The impact of increasing stocks of tractors, as opposed to making the hire market more efficient, differs little in aggregate labour displacement, but appears to involve heavier displacement of family labour under the intensive system. This is attributable to the substantially lower use of family labour in 4wt owning farms at Kaudulla (where System A is practised) than elsewhere. In view of the small numbers of observations involved, part of this difference may be spurious (Table 4.1.4).

4.4: The Overall Impact of Tractorisation on Labour Use

Drawing together the complex types and levels of labour displacement effect of tractorisation discussed in 4.1-4.3 above, we might conclude that the impact of replacing buffalo by one 4wt differs substantially according to the method of buffalo husbandry and use that it displaces, but not according to whether it results from an expansion in the volume of hire obtained from existing tractors or from an increase in the tractor stock.

Where an intensive buffalo husbandry system is displaced by one additional 4wt, the loss of almost 1,000 days p.a. of work is noted,[2] the bulk of this relating to herd maintenance and affecting family, not hired, labour. With the displacement of an extensive buffalo system, loss of work in agricultural activity forms the bulk of the 500 days displaced, the impact on hired and family labour being roughly equal.

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[1] It is recognised that the combination of maintenance and use systems are not unique: at Padaviya, for instance, the use of ploughs was widespread in a husbandry system which relied heavily on open grazing.

[2] This corresponds closely with independent estimates (by e.g. Burch (1980) p.192, that one 4wt displaces 5 workers, though Burch mistakenly assumes that the impact will be entirely on hired labour.

Whilst tractor owners generate higher employment in non-farming activities than do buffalo owners (Table 4.2.2), it would be erroneous to assume that this entirely represents a net addition to employment, i.e. one which could not have been achieved in non-tractorised systems. The magnitude of the impact (some 65 days p.a. for 4wt over buffalo owners and 19 days for 2wt owners) is in any case small compared with the displacement from agriculture and maintenance. It has not proved possible to extend the analysis of employment generation into such other 'indirect' channels as tractor sales and service, veterinary services, the construction and maintenance of implements and so on. Some of these effects will, in any case, be self-cancelling in terms of the numbers of workers affected, though there may be qualitative differences.[1] Overall, it is unlikely that any net effects that might result would require major amendment to the overall impact, of which agricultural employment and buffalo herd maintenance are the main components.

[1] Expanded tractor use may, for instance, demand on the whole, a more highly skilled workforce.

CHAPTER 5 - THE DISTRIBUTIONAL IMPACT OF MECHANISATION

In Chapters 2 and 3, discussion centred on the impact of mechanisation on production; its distributional impact on the volume and composition of employment was considered in Chapter 4. We now turn to a more general discussion of the effects of mechanisation on the distribution of income and wealth among farming communities, attempting in the final pages of this chapter to quantify in simple models the distributional changes that have occurred through mechanisation.

5.1: Patterns of Income, Indebtedness and Draught Power Control - Historical Perspective[1]

In the opening pages of this study the significance of small farm mechanisation in the Dry Zone as an issue meriting economic investigation had to be traced back to those policies designed to cope with chronic food deficits and the limited scope for expanding crop production in the Wet Zone. Similarly, the distributional impact of mechanisation can only be understood adequately against a background knowledge of, first, traditional patterns of access to draught power resources, and second, the impact on these of the transmigration and social disruption inherent in major colonisation.

(i) Traditional patterns of access to draught power

Evidence from the earliest periods of hydraulic civilisation in the Dry Zone testifies to the economic, social and religious significance of cattle and their by-products.[2] The use of animal draught appears to have been the norm in both the cultivation and threshing of paddy from these earliest times. Trains of ox wagons were employed in the transport of commodities over large distances, and both oxen and buffalo were used to power oil extraction and water lifting equipment. Buffalo hair and bone has long been used in rituals performed in connection with paddy cultivation, as have bonemeal and manure as a fertiliser. Ghee, made from the milk of cows, has traditionally been used as lamp oil in religious sanctuaries.

The ownership distribution of draught animals was as wide as these use patterns suggest: the king, religious institutions and individuals are cited as the three categories of ownership.[3] Payments in kind for the use of animal draught were the norm: the services of pack bulls and draught buffalo were requisitioned by the king from individuals, in return for various

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[1] This section draws heavily on material submitted to the Study by its Consultant in Sociology, Dr. W. M. Sirisena of Peradeniya University.

[2] Sources are too numerous to list here. They include the Culavamsa and Mahavamsa chronicles of the Anuradhapura period and numerous stone inscriptions bearing royal proclamations. These are reviewed by Siriweera (1981) in a paper commissioned by this Study, and the opening paragraphs in this section draw heavily on his report.

[3] Siriweera, (1981) p. 24. Frequent references to the branding of cattle testify to the significance of individual ownership.

privileges. Land was granted in payment for tending the royal herd.[1] Payments in kind(often in the form of a calf) for herding were commonplace, as was the trading of oxen and buffalo for money. Individuals could therefore build up a small herd of draught animals both through financial outlay and through the supply of their own labour services. Reciprocal arrangements among individuals for the use of animals were commonplace and normally involved transactions in kind. Thus, the ancient share cropping ('ande') arrangement which has continued to modern times, required the landlord to provide seed and draught inputs if he were to qualify for a half share of the harvest. When the landowner could not supply buffaloes he had to pay the tenant yoke hire ('viya-kuliya') or forego part of his crop share. Payment for buffalo hire throughout the eighteenth and nineteenth centuries remained on a crop share basis, varying, according to the local availability of animals, between 1 and 2 bushels of paddy for the ploughing of an acre, payable at harvest. Alternatively, in some circumstances,[2] the hirer could pay by working for a specified period on the owner's farm.

This brief summary can only sketch the main trends in patterns of ownership and use of draught animals in the pre-colonial period. The most important features of such systems, however, lay in the predominance of reciprocal arrangements for herd use, in the wide scope for that most abundant resource - human labour - to pay for hire or purchase of animals, and the widespread deferral of crop share payments until the end of season. Financial transactions thus formed a much smaller proportion of total hire or purchase agreements than they do now, and payments - in both cash and kind - could be arranged to follow the harvest, thus preventing overt and chronic indebtedness. Some of the traditional practices outlined here appear to have been carried down to present day villages: whilst some individuals, particularly in the Dry Zone, continue to own large herds, the ownership of small herds in both Wet and Dry Zone villages is common, with individuals pooling small herds or borrowing animals from large herds to make up teams ('kerullas') of several pairs for mudding and threshing. The hiring of animals with payment on an exchange labour or crop share basis remains common in these traditional societies, though the scope for payment through labour is reduced with the emergence of the wage labour economy.

(ii) The impact of colonisation

Traditional methods of pooling draught animals, of deferring payment for their use until after harvest or of relying on labour services as a payment require the inter-personal trust, familiarity and social cohesion normally evident in small communities (such as traditional 'purana' villages in the Dry Zone) for their efficient functioning. The prospects for their continuation in large artificially created settlement communities are remote. The diverse origins of settlers and their heterogeneous composition within

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[1] A remarkable degree of sophistication in animal husbandry was achieved in this early period, much of which appears subsequently to have been lost. The papancasudani written in the 5th Century A.D., for instance, catalogues the duties of a herdsman in rotating grazing sites and in providing the special care perceived as necessary to both the 'herd leader' and to smaller and weaker animals. During the monsoon periods, cattle pens were to be fumigated to rid them of harmful insects.

[2] A traditional reciprocal arrangement known as 'kaiya'.

even small sub-areas of settlement schemes have prolonged links between the settler and his village of origin and delayed the emergence of social cohesion within settlements.[1] Evidence of this is found particularly in the absence of spontaneous pressure groups organised to campaign in issues of common interest such as water supply.[2] The respect for such traditional leaders as the teacher, the herbalist or the Buddhist monk appears to have declined whilst the consumption of alcohol and narcotics are claimed to be widespread.[3]

Traditional methods of access to draught power appear to have been replaced largely by the market mechanism. Whilst the pooling and rotational use of small herds was common in Kaudulla, direct hiring appears to have been the most common access mode in Padaviya and Uda Walawe. Payment for animal hire is still frequently deferred to the end of season, but the provision of labour services by the hirer as payment has now been completely displaced with the prevalence of wage labour on settlement schemes. Herding arrangements still involve part-payment of the herdsman in kind (i.e. by a share of the calves born under his management), so that it remains possible for (a few) individuals to build up herds of their own by this method.[4]

Undoubtedly, the degree of social cohesion observed in major irrigation is far below what the architects of colonisation policy would have desired.[5] Furthermore, the role of cash transactions in the farm economy has increased enormously: improved seed now has to be bought whereas three decades ago seed was normally retained from the harvest; the responsiveness of such seed to fertiliser, insecticide and fungicide applications requires cash expenditure on these by contrast with the organic manures which were formerly collected only by expenditure of human labour. At the same time, the scope for individual farmers to pay for inputs - or to generate them - by their most abundant resource - family labour - has declined. 'Kaiya' arrangements for providing labour services to pay for draught power have, for instance, virtually died out.

The effects of this expanding role of financial transactions have been particularly acute in the early part of the season when cash is in any case likely to be short. They have led to an increased reliance on informal sources of credit, particularly from the local trader. The lack of social cohesion in settlement schemes and absence of the paternalistic help in times of crisis still evident in some village societies, have made the effects of this monetisation particularly acute there.

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[1] Settlers at Padaviya, for instance, were drawn from all 23 Districts of Sri Lanka. In the sociology survey of this study over half of those responding knew of fewer than 10 families from their area of origin settled within the same Tract.

[2] The only successful spontaneous societies appear to be those of a non-political nature, with a highly specific objective such as Death Donation Societies.

[3] Sirisena, W. M. Personal communication.

[4] Others can, in principle, resort to cash purchases. In practice, however, the market for working animals is poorly developed (possibly a reflection of weak social organisation) and difficulty may be experienced.

[5] For a discussion of these aspirations, see Farmer (1957).

Official attempts to cushion the effects of increased reliance on cash inputs through schemes for providing seasonal credit to farmers have been largely ineffectual. The reasons for such failure cannot be analysed in depth here; they include poor management, corruption, non-enforcement of loan recovery, and a reluctance by farmers to meet repayment schedules which has been fostered by frequent politically related moratoria on outstanding debts.[1] Thus, over 75% of our samples did not apply for seasonal credit in 1979-80, principally because they were ineligible through previous default, and a further 15% of those who did apply were denied credit for various reasons.[2] There has thus emerged precisely the same vicious circle of informal credit and indebtedness on settlement schemes as in villages, which colonisation policy sought to avoid:[3] some crisis disturbing the normal pattern of events (a poor harvest, illness, the need for a dowry, the need to contribute to children's education expenses) leads to the farmer's offering part of his land (normally his only collateral) as security against a loan from the village trader. Cultivation rights pass to the lender until the loan can be repaid - frequently impossible with revenue only from the remaining land.[4] Less severe crises may be met by pawning household goods at interest rates of 15-20% per month[5] or by credit purchases of consumer goods (commonly at a premium of 10% over their retail price instead of an interest rate) or of crop inputs. A frequent condition of credit repayment is that part of the borrower's paddy be sold (at a discount) to the lender.

(iii) The advent of mechanisation

Set against this background of increasing indebtedness, and increased concentration of productive resources into the hands of a small and wealthy sector of the community, it is not difficult to predict the impact of mechanisation on distributional flows. The price of a 4wt in 1979-80 exceeded that of a pair of buffalo by a factor of almost 100, whilst even the price of a 2wt was ten times that of a pair of buffalo. This, combined with the distributional incidence of subsidies on the purchase and official hire of tractors, biased access opportunities towards the articulate, politically favoured or already wealthy sectors of the community.[6] Tractor pools were established in areas of larger-than-average farm size, and the first private owners of tractors were large landowners, closely followed by village traders who perceived the benefits of tractors in both transport and agriculture. Subsequent efforts to spread the benefits of tractorisation more evenly have included elaborate schemes to ensure that subsidised credit for their purchase is allocated only to bona fide farmers.[7] In spite of such

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[1] For further discussion of patterns of indebtedness and sources of credit, see Amunugama, S. (1964), Central Bank (1972), Jayaweera (1973), Kurukulasuriya (1971), Harriss (1977).

[2] Table A.5.3.1, Appendix 5.1.

[3] Farmer (1957) Chapters 3-5.

[4] Loans advanced against this 'mortgaging' of land (as it is known) varied from Rs.2,000/acre at Kaudulla, where land is normally double-cropped, to Rs.500-800 at Padaviya in 1979-80. Fixed term leasing could raise lesser amounts of Rs.300-Rs.1,000/acre per year. Sharecropping ('ande') is uncommon, being practised only by those with insufficient labour (such as widows) to manage the plot.

[5] The range of each study location.

[6] For detailed evidence on the distribution of benefits arising from these sudsidies, see Burch (1974 and 1980).

[7] As provided by Parker (1978) for the TIMP.

provisions, half of the sample 4wt purchased under an officially subsidised credit scheme at one of our locations fell into the hands of traders or government officials.[1] There is no reason to suppose that this pattern of allocation is atypical of a wider trend: tractors appear to have been acquired disproportionately by those already wealthy.

As discussed above, traditional methods of sharing draught resources - by borrowing a pair or two of animals, by the rotational use of pooled herds, by working in the owner's fields in return for the draught he provides - made animals available to those without adequate cash either at the time of ploughing or later in the season. There is evidence that these pro-equality practices were being eroded before the advent of tractors: owners of buffalo at Uda Walawe - traditionally an area in which large herds are kept by wealthy individuals - provided less than 0.1% of their draught services to others free of charge. At Padaviya, with its slightly smaller herds, this rose to 14.0%, but at Kaudulla, with very small herds, the need for reciprocal non-cash arrangements seems to have survived, since 81.3% of services were made without direct payment in either cash or kind. A far smaller proportion of unpaid services were rendered by tractors in all cases - 1.6% overall for 4wt and 1.7% for 2wt, indicating that tractors represent a major force in further monetisation of the economy, and in the removal of former pro-equality practices. What is equally relevant to the present discussion is that they require an increased cash outlay by the hirer at a time of year when he is already under severe financial strain. Tractor owners face a pattern of recurrent expenditure for fuel, servicing, repairs and drivers' wages which is largely determined by the time pattern of their activity. They are generally unwilling to defer payment for hire to the end of season and the payment of 4wt alone is currently as large as payments for all other inputs combined.[2] Of all field operations performed on hire by our 4wt sample, only 20.0% were on a deferred (i.e. to the end of season) payment basis, and only 6.9% accepted payment in kind. For 2wt, the respective proportions were 15.2% and 2.6%, whereas 65.3% of buffalo operations were deferred, and 53.0% were in kind.[3] The hiring of tractors on an 'immediate cash' basis thus raises the farmer's financial commitment at a time of severe cash flow constraints compared with what it would be under a deferred payment buffalo hire.[4]

In the remainder of this chapter, we attempt to quantify from field survey data the timing and volume of the impact of this component of increased commitment to financial transactions in the budgets of both owners and non-owners.

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[1] Of the 8 sample 4wt purchased under the TIMP at Padaviya, 3 went to businessmen and one to a government official. It is evident that numerous schemes to import tractors in the last two decades for food production purposes have similarly failed in their objective of putting tractors into the hands of farmers. Burch (1980) for instance reports that of the 1,000 4wt imported under British Aid in 1972, only 175 went to bona fide cultivators, whilst 441 went to other individuals, 67 to co-operatives, 230 to government departments, and the remaining 87 to estates and local government bodies.

[2] The average non-owner in our samples paid Rs.432 p.a. for 4wt hire, against Rs.444 for seed, fertiliser, fungicides, insecticides, etc. (Appendix 5.1., Tables A.5.1.11-A.5.1.12).

[3] A very high proportion of the 4wt 'deferred' and 'kind' payments were for threshing, which is virtually at the end of the season, so that the benefits of deferral are negligible.

[4] It should also be stressed that in periods of rapidly rising operating costs tractor owners have acted as price leaders in the hire market. The lack of competition in this market (see Ch.6.2) has allowed buffalo owners to follow suit, so that the terms of trade have been shifted against non-owners, with severe distributional implications.

5.2: Income and Expenditure Patterns of Non-owners[1]

In general, a location-wise breakdown of income and expenditure produces only minor deviations from the following general patterns:

1. Cash earnings per household at the tail ends of command areas (average Rs.2,586.40 per annum) are less than half the corresponding top end earnings (average Rs.6,588.20 p.a.). The main reasons for this are smaller proportion of irrigated land in the operated holding of tail enders,[2] fewer opportunities for creating irrigated encroachments onto roadside or canal reservations,[3] or for irrigating parts of the holding designated as 'highland'.[4]
2. Reliance on sources of off farm income was heavier at the tail ends. For instance, at the tail end of Uda Walawe, the contribution to cash incomes from off farm activity amounted to 36.3% against 6.1% at the top end.
3. Within the contribution to income from crop sales, the role of paddy sales fell relative to that of other crop sales from top to tail ends. At Uda Walawe, for instance, paddy accounted for 97% by value at the top end, whereas[5] in the two tail end groups is contributed 28.0% and 2.5% respectively.
4. Of the income derived from off farm work, the bulk was attributable to the hiring out of labour for agricultural purposes. Reliance on this source, however, increased from top (36.0% of all earnings) to tail (61.4%). On the other hand, the contribution to household income of earnings from white collar employment was largely limited to top enders,[6] corresponding with their higher educational achievement.
5. Returns from crop production per day worked are generally higher at the top than at the tail ends, though individual differences in yield levels prevent firm conclusions.[7] On the other hand, because of the relatively low purchase of cash inputs, the cost of producing a bushel of paddy is lower at the tail than at the top ends.[8]
6. Across all locations, 70.5% of the mean cash income was spent on inputs for crop and livestock production and on the purchase of household items.[9] The proportion of income expended on these items rose from under 70% at the top ends to almost 80% at the tail ends.

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[1] For detailed tables and methodological notes, see Appendix 5.1.

[2] See Tables 3.4.1-3.4.2.

[3] For details see Part 1 Report, Appendix II.

[4] A common practice in the upper reaches of Kaudulla, where some 'highland' plots are, in fact, below canal level.

[5] The availability of irrigation water acted as a major determinant of cropping patterns: crops with low water requirements being grown only where the availability for irrigated paddy was likely to be inadequate.

[6] For Uda Walawe and Kaudulla, top enders received 26.0% and 8.5% of their income from this source, against zero for tail enders. At Padaviya, the mean figures were 33.4% and 7.1% respectively. For details of educational achievement, see Appendix 5.1.

[7] For details see Appendix 8, Table A.8.1.

[8] The reverse if true when a cost for family labour is imputed at the current wage rate.

[8] Of an individual value exceeding Rs.20. See Appendix 5.1.

[9] Against under 1% of recurrent expenditure (i.e. not including medium term loans) for the owner sample.

7. Of the individual expenditure items, hired labour accounted for 35.5%, farm power for 30.0%, other crop and livestock inputs 13.5% and the repayment of short term credit 11.4%. Apart from labour, farm power is thus the largest single cash expenditure item in the farmer's budget.
8. Approximately 20% of expenditure items were financed by credit, the proportion being slightly higher at tail (22%) than at top (15%) ends in spite of the much lower absolute levels of expenditure at the tail than at the top ends (Rs.2,635 against Rs.4,351 per household per annum). The overall share of credit finance in the hire of draught power was no higher than this, but only 7% of draught hire was financed by credit at the top ends, against 32% at the tail ends.
9. Official sources of credit accounted for slightly over 50% of borrowings at Padaviya, but were much less significant at the two other locations, so that private sources (especially traders and moneylenders) were by far the most important source overall. Whilst over one-third of the sample successfully applied for official seasonal credit at Padaviya, less than 20% did so at the two other locations, chiefly in view of their ineligibility through previous default.
10. Predictably, the pattern of income and expenditure is highly seasonal, income outweighing expenditure only in the few weeks following each season's harvest.

The overall scene is thus one of income levels comparable with those observed at other major irrigation schemes.[1] If day-to-day household expenses were added to these figures, they would approach the national average consumption expenditure.[2] Within major schemes, however, sbustantial differences exist between top and tail ends, with tail ends having to rely on earnings from casual labour for a much higher proportion of income. Whilst overall reliance on credit does not appear to be high, it is more prevalent at the **tail** ends. Private traders and moneylenders are the predominant source of credit.

The impact of mechanisation within this context is not uniform: farmers on adequately irrigated land, for instance, appear to have little difficulty in providing the necessary cash for prompt payment of hire charges. At the tail ends, however, the resources and opportunities available to farmers for converting their labour into cash are more limited, so that a larger proportion of those hiring in draught power have to rely on credit (32% against 7% at the top ends). In the absence of arrangements for sharing draught animals, or for paying for their hire directly through labour services, draught power charges constitute a major cause of indebtedness to private moneylenders at the tail ends. In locations where small herds of animals are widely owned,[3] non-cash arrangements for sharing buffaloes are common, and this in itself constitutes a major argument in favour of official support for the more widespread ownership of draught animals.

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[1] See ARTI (1979a).

[2] Average annual private consumption expenditure per family was over Rs.7,000 in 1979 (Department of Census and Statistics, 1980).

[3] i.e. Kaudulla in the present context.

5.3: Income and Expenditure Patterns of Owners[1]

The contrast in size and composition of income between owners of different power types, and between owners and non-owners is immediately apparent in Table 5.3.1.[2] Non-owners rely heavily on off-farm employment to supplement cash incomes, whereas owners can rely in varying proportions on income from draught power and other non-farm enterprises. Owners of 4wt, for instance, find that farming, tractor use and non-farming activities contribute to their income in descending order. For 2wt owners, farming constitutes more than half of their total net income; for buffalo owners, more than two-thirds. Given the suspicion with which questions relating to income are normally treated by respondents, it seems likely that net incomes are underestimated for all categories, perhaps particularly so for those with potentially the highest income tax liability - namely tractor owners - so that the gap between owners' and non-owners' incomes is likely to be understated by the data. It remains, nonetheless, substantial: after meeting domestic consumption and minor day-to-day expanses, 4wt owners have an annual income at least 18 times higher than that of non-owners. For 2wt and buffalo owners, the factors are 8 and 6 respectively.

By contrast with non-owners, the periods during which owners' expenditure exceeds their income are few and minor. Slight deficits were noted particularly in the months of August and September when income from farming activities was low and expenditure on preparing tractors and equipment for the forthcoming maha season relatively heavy.

The averaging of owners' incomes and expenditure across locations conceals some important differences. These are discussed in detail for the three categories of activity in Appendix 5.2. For present purposes, the variations in income and expenditure relating directly to use of the power source are of most relevance and are now summarised.

The composition of gross revenue varies widely by location. Non-farm work produces absolutely and relatively higher income than farm work for 4wt and 2wt at Uda Walawe compared with other locations, corresponding with the higher proportion of tractor time allocated to transport activities

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[1] For a detailed account of the income and expenditure patterns of owners, see Appendix 5.2.

[2] Only financial flows are considered - the retention of produce for domestic consumption being ignored among all categories. Consistently rather less than two-thirds of farm output of the main crop, paddy, was reported in the financial transactions from which these data were drawn. The acreages and yields of non-owners are smaller than those of owners, but family sizes differ little by ownership category. We might therefore assume that the remaining one-third of farm output for non-owners is necessary to feed an average family over one year (i.e. approximately 85 bushels of paddy per year, or 6.5 lbs of rice per family per day). Allowing a similar quantity (85 bu. per annum) for owners' families it would appear that a substantial portion of output which does not enter the recorded financial transactions is not needed for annual domestic consumption (some 140 bu. for 4wt owners, 75 bu. for 2wt and 45 bu. for buffalo owners). Casual observation suggests that these quantities do, in fact, enter the market - though sometimes in the form of bartered transactions - and so their imputed value is included in the data on income from farming activities.

TABLE 5.3.1: REVENUE AND EXPENDITURE PATTERNS OF OWNERS AND NON-OWNERS BY SOURCE

Source		4wt Owners	% of Total	2wt Owners	% of Total	Buffalo Owners	% of Total	Non-owners	% of Total
1) Farm Power	Gross Revenue[1]	37,894.59		8,036.49		4,278.44		-	
	Expenditure[2]	30,226.37		7,249.13		2,036.99		-	
	Net Revenue[3]	7,668.22	32.2	787.36	6.9	2,241.45	23.5	-	
2) Farming Activities	Gross Revenue[4]	18,433.19		13,831.04		8,898.79		3,824.02	
	Expenditure[5]	8,837.39		6,625.36		2,068		2,973.60	
	Net Revenue	9,595.80	40.4	7,205.68	67.2	6,830.77	71.8	850.42	48.4
3) Non-Farming Activities	Gross Revenue	8,075.10		4,553.09		1.048.96		1,104.53	
	Expenditure	1,587.14		1,151.99		610.28		197.97	
	Net Revenue	6,487.96	27.4	3,401.10	29.9	438.68	4.7	906.56	51.6
4) All Activities	Gross Revenue	64,402.88		26,420.62		14,226.19		4,928.55	
	Expenditure	38,715.48		14,296.48		4,715.29		3,171.57	
	Net Revenue	23,751.98	100.0	11,394.14	100.0	9,510.90	100.0	1,756.98	100.0

Notes:
1. For details concerning the estimation of gross revenue from power use for owners, see Appendix 5.2.
2. Includes fuel, repair and maintenance, and a substantial annual capital charge (approximately Rs.14,000 for 4wt and Rs.3,300 for 2wt - see Appendix 5.2).
3. Net revenues are slightly underestimated on a per owner basis, since some owned more than one power source, and the data presented here are per tractor, not per owner. The extent of this underestimation is less than Rs.1,000 for 4wt owners.
4. For owners, includes an imputed value for paddy produced but neither declared in financial flows not consumed by the family. See text.
5. 4wt owners' expenditure per acre is higher than that of other owners because of the larger volumes of hired labour employed.

there (Chapter 6.2). At Padaviya, by contrast, agricultural operations account for over 80% of gross revenue for both tractor types. These extremes are reflected in expenditures on fuel, repair and maintenance: the relatively light work done by 4wt at Uda Walawe[1] requires Rs. 0.18 to be spent on these items per Rs.100 of gross revenue, whereas the ratio for Padaviya was Rs.0.51 per Rs.1.00 of gross revenue.[2] High recurrent costs at Padaviya, and a high annual capital charge resulting from the relatively low age of many tractors there, caused overall net returns to be as low as Rs.217 for 4wt and Rs.438 for 2wt. At Uda Walawe and Kaudulla, by contrast, net overall returns on a 2wt were Rs.2,240 and Rs.2,301 respectively, and on a 4wt Rs.15,762 and Rs.12,251 respectively. Important differences in the profitability of tractor operations among locations thus emerge. For 2wt at Uda Walawe and Kaudulla this represents a rate of return on the average opening tractor value of some 20%, and for a 4wt of approximately 25%. Ignoring inflation and the income streams obtainable over time from investment of profits, and assuming an unchanging pattern of hire, costs and returns, it would thus take some 7-8 years at these locations for sufficient funds to be accumulated to cover the purchase price of a new 4wt (Rs.125,000 at the time of survey). Approximately the same period would be necessary to purchase a new 2wt from current 2wt operations. Given the fact that gross revenues may be underestimated through some understatement of hours worked, whereas there seems little doubt that operating and capital costs have been fully accounted for, it seems likely that these periods are upper limits of the time within which a tractor would pay for its replacement. A more realistic estimate might be 5-6 years for each tractor type, which for 4wt is well within the conventional estimate of a tractor's working life in Sri Lanka (10 years for 4wt; 5 years for a 2wt).[3] Even with these provisos, however, it is clear that tractors are barely a worthwhile investment at Padaviya. The apparent suplus of farm power there[4] is one of the causes of this; the unsold TIMP tractors at Padaviya[5] one of its effects.

These rates of net return, and the volume and composition of work from which they are drawn, bear interesting comparison with those derived from other studies. From such comparison inferences can be drawn regarding changes in the profitability of tractor operations over time. A broad cross-check on the validity of current data can also be obtained. This would take us outside the scope of the present discussion of owners' and non-owners' incomes, and is reserved for the next chapter. Suffice it to say, however, that such comparisons suggest no reason to doubt the validity of the data presented here, with the possible exception that the returns for Padaviya may be atypically low.

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[1] Even when used in agriculture, 4wt were rarely employed outside threshing and the transport of agricultural goods.

[2] It is conceivable that major repairs on several of the older 4wt at Padaviya caused this cost extimate to be inflated.

[3] Further, it should be stressed that these rates of return are obtained at use-levels far below those commonly assumed necessary to make tractor operation profitable, which suggests that annual profits are maintained by hourly rates of charge higher than they would need to be with more intensive use.

[4] Chapter 2.5.

[5] Chapter 2.4.

CHAPTER 6 : FARM POWER AND WATER USE : PERFORMANCE AND PROSPECTS

In chapters 3-5 the attempt has been made to quantify the detailed impact of tractorisation on production employment and distribution. Both the mass of field survey data from thepresent study and published and unpublished work from other sources were drawn upon. Some of the estimates can be made with reasonalbe confidence: tractorisation does not appear, for instance, to have significant yield, timing or cropping intensity effects in irrigated farming. Similarly, wide agreement now seems possible on the size and composition[1] of its employment effects in agriculture and to a lesser degree in maintenance of the power source. Other 3 effects can be only approximately quantified mainly owing to the lack of information in activity levels that might have existed in the absence of tractors. Thus, the impact on employment and income generation in non-farming enterprises solely attributable to tractorisation is difficult to quantify. Similarly, the possibility of respondent underestimation of income flows and the difficulty of separating out the impact of tractors from those of diverse other enterprises make quantification of the distributional impact of mechanisation problematic, though it can be stated with certainty that the direction of its effects has been towards greater inequity, and its impact moderately strong.[2] Again the overall impact on cultivation intensity of non-paddy lands is difficult to quantify since it is likely to vary widely according to the local availability of un-or under cultivated upland and since the rates of exploitation of this resource that might exist under manual or draught animal systems are not known with certainty. Below we attempt a synthesis of these findings.

6.1. The costs and benefits of small farm mechanisation in Sri Lanka Some Exploratory Calculations

A detailed and methodologically sophisticated social cost-benefit analysis of small farm mechanisation lies somewhat outside the scope of the present study; the continued need to rely on assumptions for some of the most basic parameters would in any case, outweight part of the potential advantage attributable to methodological sophistication. There is for instance no reliable estimate of the size of the tractor stock in working order. Nor can accurate estimates be made of the annual consumption of spare parts. Some preliminary calculations are, however, possible. The methodology adopted is briefly as follows:

Cost. Four major items are taken into account: for the purchase cost of tractors, the cost of spares necessary over the life time of a tractor, and for fuel costs, overt or implicit subsidies (through for instance, an over-valued local currency) are allowed for so that as far as possible the prices used are those obtaining at the national border, not at the farm gate. For labour the oportunity costs of engaging additional staff in farming non-farming activities and tractor maintenance were estimated. The social costs arising from higher concentrations of wealth in the community and the greater control over informal credit which the owners of tractors can exert could not be

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1 Between family and hired labour

2 Relative to such other potentially differentiating enterprises such as the ownership of retail stores or draught animals.

3 For a detailed account, see Appendix 6.3

adequately quantified for inclusion. Details of the assumptions used are given in Appendix 6.2.

Benefits. The analysis sought to isolate the benefits solely attributable to tractor operations. In cases where tractors merely substituted for animals in agricultural and non-agricultural work, it was assumed that the only benefit would be that of reduced labour costs for the work in question and for herd maintenance.[1] In cases where tractors make a positive contribution to output over and above that currently achieved by animal draught, quantitative estimates of this contribution derived from the main body of this report were incorporated. A positive production impact can be achieved through earlier planting, higher yields, increased cropping intensity and expanded acreage. The evidence presented in Chapter 3 suggested that the only substantial benefits in Sri Lanka lay in expanded acreage of rainfed lands,[2] and increased cropping intensity on these. No yield increase, timing advantage or switch to higher value crops was evident. Benefits also accrued through tractor use in those transport activities which would be difficult or impossible to perform through animal draught. The role of tractors in haulage contracts and in transport related to owners' business activities was accounted for by their observed contribution to owners' income from these enterprises. Spin off effects on the community through more rapid transport may also have occurred, but were impossible to measure empirically. They are accounted for here by a 'guesstimate'.

The analysis presented here is therefore limited: it has to be constructed by extrapolations of and assumptions based on data specific to time and place. Furthermore, a number of less readily quantifiable costs and benefits are not taken into account. Data published in other studies (Carr, 1975; Harriss, 1977; Burch, 1980) permitted some cross-checking of the assumptions used here. In spite of the approximate nature of some of the estimates, the results provide valuable insights into the likely size and composition of costs and benefits.

On the assumption of:

i) a contribution to agricultural output solely attributable to mechanisation of Rs.5,000 per 4wt-year for each tractor engaged primarily in farm activities, but no corresponding contribution by 2wt;
ii) a gross benefit solely at ributable to mechanisation of Rs.24,000 per 4wt-year and Rs.3,000 for each tractor engaged only in non-agricultural activities;
iii) a portion of these non-agricultural benefits attributable also to agriculture-based tractors in respect of the time they spend in transport;
iv) a hired labour requirement in farming, driving and maintenance of 137 days per 4wt-year against 255 per year for operating the buffalo displaced by one 4wt (72 and 168 days respectively for one 2wt);

[1] Benefits potentially derivable through a transfer of animals to milk or beef production, or through the release of grazing land to other opportunities have not been realised to any significant degree in Sri Lanka, and so were not taken into account.

[2] Tractor owners' paddy holdings were larger than those of non-owners, but this represented almost exclusively a redistribution within the productive system, not a net addition to production attributable to tractors.

v) a continuing stream of benefits and (recurrent) costs for 10 years from those 4wt and 5 years for 2wt continuing in use after the end of our 1953-79 reference period.

The 4wt stock imported in the period 1953-79 appears to have generated a total net disbenefit of Rs.2,400 million[1] to the national economy. For 2wt in 1970-79 the disbenefit was approximately Rs.345 million.

Putting this figure into perspective, it implies that only 70% of the aggregate cost of purchasing, maintaining and operating 4wt during the reference period has been recovered through benefits attributable directly to tractorisation. Surprisingly, more than two-thirds of these benefits arise from non-agricultural work, the remainder comprising benefits from agricultural work to a slightly higher extent than from labour savings. The lack of agricultural benefits directly attributable to 2wt and their lower capacity for non-agricultural work, resulted in a relatively poorer performance, only 44% of cost being recovered.

A brief sensitivity analysis revealed that these results are little influenced by a major change in assumptions concerning the size of the working tractor fleet: if the working 4wt fleet in 1979 is assumed to be 15,000 4wt instead of 9,500,[2] disbenefits rise only slightly, to Rs.2,600 million. The choice of an 8% discount rate instead of 10% reduces disbenefits from Rs.2,400m. to Rs.2,100m.

The possibility that part of this result is attributable to some underestimate of the potential benefits of mechanisation, or overestimate of its costs, cannot be entirely excluded. Where assumptions have been particularly uncertain, the attempt, however, has been to err on the side of generosity towards tractors. For instance, the cost of repairs and maintenance[3] has been taken as 40% of the initial tractor value, as against the 130% commonly adopted.[4] Further, the higher costs incurred for purchase and maintenance of tractor implements and trailers over those for draught animal equipment were ignored. For the net effect of mechanisation to be positive, the value of benefits would have to be approximately 50% higher than those estimated here, without any cost increase. Whilst some uncertainty attaches to the estimation of benefits from mechanisation, it seems improbable that they could have been underestimated to this extent here.

Two remaining issues require discussion :

First, it may be argued that the expansion of small-farm agriculture in Sri Lanka since 1953 has been so substantial that constraints in draught animal feeding and management would have prevented the tilling of more than a fraction of this increase by traditional methods. According to this argument

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[1] Prices are current for each year in question, but annual net (dis)benefit streams are reduced to a net present value at a 10% discount rate.

[2] With corresponding adjustments each year back to 1964.

[3] Excluding labour charges, see Appendix 6.2.

[4] At 1979 prices.

the net costs involved in tractorisation were necessarily incurred since no practicable alternative was available.

The asweddumised acreage has, indeed, expanded substantially - from 964,484 acres in 1952-53 to 1,613,978 acres in 1978-79. However, it is difficult to accept this line of reasoning: whilst the supply of grazing land for traditional open-grazing herd management is declining, there remains abundant scope for technical improvement in animal management. Stall feeding has been adopted in only a small part of the Sinhala Dry Zone.[1] It involves the feeding of cut grass only and so is still at a low stage of technical development. The relatively low resource pressures in the Dry Zone could undoubtedly support far larger populations of draught animals than hitherto at very low opportunity cost, so that the balance of evidence suggests that it would have been feasible and cheaper to cultivate the 67% increase in asweddumised acreage from 1953-79 by animal power.

Second, if tractorisation has indeed been as costly to the national economy as these figures suggest, why was it adopted so widely over such a long period? Economic analysis can provide only a partial answer to this question: subsidised foreign exchange, tax concessions, subsidised fuel and subsidised hire rates in tractor pools are among the many fiscal and monetary measures which made tractor power cheaper at the farm gate than at the national border. Added to this are the reinforcing effects of cheap credit for tractor purchase, high rates of default on repayment, and substantial private benefit to tractor owners through the redistribution of existing paddy lands and business activities in their favour. The combination of these factors serves to make tractorisation an attractive strategy to the farmer, even though costs may outweigh benefits at the national level. Individual farmers' and businessmen's desire to capitalise on these private benefits undoubtedly contributed to the emergence of a second set of pressures: in return for political allegiance at the local level, they demanded allocations of tractors from central authorities, so that tractors became a central feature in cementing the patron-client relations highly characteristic of the Sri Lankan political and social order.[3]

No serious economic attempt has been made hitherto to assess the costs and benefits of tractorisation. Even if it had, it is doubtful whether even strong negative economic evidence would have been sufficient to outweigh the political significance attaching to tractorisation policies. With the increasing role of aid donors in supplying tractors to agricultural projects in recent years, the prospects for influencing the composition of the draught

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[1] Another factor which sheds a particularly favourable light on tractorisation in the above analysis is that buffalo labour costs were taken as the mean between stall feeding and open grazing systems, though open grazing remains by far the more predominant (and cheaper) system in the Dry Zone.

[2] Indeed, much of this increase could be tilled by more intensive use of the existing draught animal stock. The expansion of non-asweddumised (i.e. rainfed) farming would, in the absence of suitable zero tillage techniques, have required 4wt, given the hard soil conditions at the end of the dry season and the high returns to timely cultivation. The most appropriate strategy, however, would have been an expansion in tractor use among those farms specifically concentrating on rainfed farming. An attempt to pursue such a strategy under the 1966-70 Special Leases Scheme was a complete failure, tractors being diverted into activities which were more profitable in terms of private costs and benefits. As far as paddy land is concerned there is evidence of a substantial expansion in acreage corresponding with long periods during which the tractor stock remained static - especially in 1970-77 (see Appendix 2, Table A.2.1).

[3] A stimulating account of the processes underlying these relations is provided by Burch (1980).

power stock through forces other than the entrenched attitudes of the Sri Lankan administration have increased. Hitherto, donors have been in favour of supplying large numbers of tractors, and so their influence has merely served to consolidate existing trends. It is hoped that the result presented above will persuade them to take a more cautious approach towards the future role of tractors in smallholder farming in Sri Lanka.

6.2: The Scope for Increasing Tractor Use-efficiency

To state, as we did in the previous section, that the costs of mechanisation have heavily outweighed the benefits during the last three decades, does not imply that no potential exists for reversing the situation. Considerable inefficiency and unused capacity currently exists in tractor use. In this section some of the ways in which this might be reduced are explored.

6.2.1: Use levels of farm power

Mean weekly use levels by power type and location are given in Table 6.2.1. The survey embraced 59 weeks from the end of August, 1979, twice covering the part of the busy late yala/early maha period that falls in August/September, so that use levels when converted to an annual basis might be slightly over-estimated. Even so, they remain low, at:

> 734 hrs. p.a. at Uda Walawe, 627 hrs. p.a. at Kaudulla and 497 hrs. p.a. at Padaviya per 4wt; 486, 340 and 420 respectively per 2wt and 329, 259 and 288 respectively per pair of buffalo.

When the figures are re-computed using week means derived from only those power units observed to be working during the week in question,[1] the means are raised to 900-1,000 hrs. p.a. per 4wt, and 600-800 hrs. p.a. per 2wt.[2] Use-levels reflect the pattern of agricultural production - at Padaviya where a yala crop was not grown, use-levels of (especially) 4wt are low. Similarly, the proportions of work in agricultural and non-agricultural uses reflect the opportunities for non-agricultural work at each location, with almost 50% of 4wt time at Uda Walawe allocated to non-agricultural uses against less than 20% at the most remote and commercially underdeveloped of our three locations, Padaviya.[3]

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[1] This revised basis of computation does not imply that several tractors which had been inactive for long periods were excluded. Whilst a few tractors did fall into this category, chiefly as a result of breakdown, the general pattern was for tractors to be withdrawn from work for one or two weeks at a time, as a result of temporary breakdown, other pressing commitments among the owners, the inability to find conveniently situated work and so on. It is predominantly these temporary withdrawals which are allowed for in the revised computations.

[2] Multiplication of the relevant weekly average for buffalo in Table 6.2.1 by 52 weeks gives over 1,000 hrs. p.a. per pair. It would be misleading to regard this as an accurate reflection of annual buffalo use intensities, however, since they are used only for short periods at land preparation and harvest.

[3] For a detailed discussion of the pattern of maha use intensities, see Part 1 Report, Chapter 3.2.

TABLE 6.2.1: MEAN USE LEVELS OF FARM POWER OVER THE STUDY PERIOD BY TYPE AND LOCATION (HRS/WEEK)

Operation Type[1]	UDA WALAWE				KAUDULLA				PADAVIYA			
	Hrs/week over Entire Sample		Hrs/week over those power units actually used[2]		Hrs/week over Entire Sample		Hrs/week over those power units actually used		Hrs/week over Entire Sample		Hrs/week over those power units actually used	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
4wt (all agricultural non-agricultural)	14.11	1.03	20.31	0.44	12.06	0.91	19.93	0.52	9.55	0.87	17.39	0.42
4wt (all agricultural)	8.00	1.21	11.51	0.51	7.23	1.17	11.94	0.59	7.93	1.21	14.44	0.47
4wt (non-agricultural)	7.19	1.55	8.80	0.56	4.83	0.96	7.98	0.60	1.62	0.88	2.96	0.47
2wt (all agricultural non-agricultural)	9.34	0.70	16.25	0.34	6.53	0.49	13.12	0.39	8.09	0.89	11.61	0.38
2wt (all agricultural)	7.12	0.81	12.40	0.39	4.58	0.67	9.19	0.50	6.07	0.94	8.72	0.24
2wt (non-agricultural)	2.21	0.91	3.86	0.20	1.96	0.71	3.93	0.30	2.01	0.81	2.89	0.28
Buffalo[3] (all	6.33	0.41	28.84	0.79	4.94	0.37	21.56	0.57	5.54	0.38	21.35	0.67

Notes:
1. Agricultural operations are defined to include the transport of agriculture-related goods. Non-agricultural operations are confined to other haulage and passenger transport.
2. Since some power units were not used during certain weeks, this mean is given for those actually in use in each of the weeks in question. (See text).
3. In the case of buffalo, means are given per pair, and the higher of the two means is obtained on the basis of owners using buffalo during the individual periods in question. Buffalo are used only in agricultural operations.

The use levels over our whole samples are substantially lower than those postulated for economic use of tractors in numerous (foreign aided) investment appraisals. A small farm credit proposal for 1979, for instance, estimates that small farmers will obtain a financial rate of return of 23% on 4wt investments over a 10 year period if they are used at 1,000 hrs. p.a. At 600 hrs. p.a. the return falls to almost zero.[4]

Contrary to our earlier suggestion (Chapter 2) the use intensity of buffaloes among the large herds at Uda Walawe are significantly higher than elsewhere (P=0.05). The problems of managing large herds in hire contracts do not therefore appear to have been as great as we had anticipated. This is, no doubt, in part attributable to the relatively unproductive tillage techniques used at Uda Walawe ('mudding') which permit large numbers of animals to be deployed in a single liyadde. The longer durations of use per buffalo-pair at Uda Walawe are just adequate to compensate for the higher per acre time requirements of this method vis-a-vis ploughing (Table 3.2.1).

The substantial difference between the two sets of means - the first calculated over the entire sample and the second with a reduced sample in which the individual week means are computed only for those power units observed to be working during the week - suggests that the withdrawal of a power unit from the market for at least a week at a time is a major source of low use intensity. The reasons for non-use are discussed separately in Appendix 8, the lack of perceived use opportunities being a major source of low use intensity.

It is not easy to define the factors underlying owners' perceptions of appropriate use opportunities in this regard. Certainly, no single objectively defined set of criteria seems to apply. Some 4wt owners, for instance, sent their tractors over to parts of the Wet Zone in the effort to obtain contracts for the transport of construction materials during the off-season. Others apparently felt that this effort would prove unrewarding. The operation of 4wt (and, more frequently, of 2wt) was sometimes purely a family concern, which did not rely on the employment of hired drivers. Availability for the hire market was therefore inversely correlated with the period of peak own-farm activity, during some of which the tractor is likely to have been standing idle. Further, the mechanical condition of the tractor - positively correlated with its age - may have set constraints on the type of operation its owner might wish to undertake. In informal interviews, for instance, we were told that old 4wt were widely withheld from heavy ploughing operations, and used only for threshing and transport.[1]

A further attempt was made to assess the influence of credit funded tractor purchase arrangements on their use intensity, the hypothesis being that the obligation to make substantial monthly loan repayments would oblige owners to use their tractors more intensively (c.f. Part 1 Report, p.167 ff). The data (Table A.6.3.2) broadly confirm the hypothesis as far as 'all operations' are concerned, though, again, the numbers of observations are small and some caution in interpretation is necessary. Whilst there is no clear pattern of differences within agricultural operations, the tendency was for much of the overall difference to be explained by higher use of credit-funded tractors in non-agricultural work. Whilst, again, we would stress the need for caution in interpreting the data in Tables A.6.3.1-A.6.3.2, they hint at the hypothesis that much of the apparently higher use intensity among newer tractors is largely specific to non-agricultural operations. This may result, among the more obvious possibilities, from some reluctance on the part of owners to submit new tractors to rigorous field conditions, from a bias in new ownership towards those with predominantly non-farming interests or from a shrinking of the market for agricultural work.

Finally, the possibility emerges that low overall use intensities result from the aggregation of successive periods of high and low use intensity, such as might be expected to occur within the agricultural cycle. Data presented in Table A.6.3.3 for the peak land preparation and harvest periods for maha 1979-80 confirm that this broadly the case, although of particular interest are the facts (i) that even within the peak periods use intensities of those tractors which were working were, at some 25-30 hrs/week, not high, and (ii) that the inclusion of those tractors not working further reduced the means. These data suggest that there is scope for increasing the use intensity of tractors in order to reduce the consumption of irrigation water in land preparation in the ways suggested in Chapter 6.3. Table A.6.3.3 suggests that increased use intensity both from expanding the working time

[1] Some evidence of this is found in the breakdown of tractor use by age presented in Appendix 6.3.

of those tractors actually in use and from bringing other tractors into more regular use (c.f. Appendix 6.3) is possible.

6.2.2: The draught power hire market

With the introduction of larger units of draught power (in the form of tractors) than had existed under traditional systems, their concentration into few hands and their sparse, irregular spatial distribution (Chapter 2) the provision of smooth and efficient means for access to their services assumes critical importance. The functioning of the market for draught power thus merits some scrutiny. No single criterion or set of criteria permits assessment of the efficiency of its operation. It is only through the accumulation of evidence on a variety of aspects of its structure and performance that a judgement can be made.

One such aspect is the share of markets held by tractors and buffalo since the escalation of fossil fuel prices in 1973. Between early 1972 and early 1980, diesel prices rose by a factor of 7.5 (Appendix 6.1). Over the same period, rural unskilled wage rates rose by approximately a factor of 3, (Department of Census and Statistics, 1980). Since wage rates are by far the major component in the costs of maintaining and using buffalo (Ryan et al, 1981), a shift in the relative hire charges for tractors versus buffalo, and a corresponding shift in their shares of the hire market, might be anticipated. Such shifts might be prevented by, for instance, a decline in the buffalo population sufficiently rapid to cause much of the potential additional demand for them to remain unsatisfied. Alternatively, any increased competition in the tractor hire market might keep down hire charges by reducing profit margins, thus stemming part of the potential shift in demand towards buffalo.

Whilst there is some debate over the direction and rate of change of the national buffalo stock (Chapter 2), for our study locations, there is no evidence of any strong decline in their numbers over the last decade. The question of the extent to which tractor owners have passed on fuel cost increases without any reduction in profit margins is hampered by the lack of a complete set of data on tractor operating costs and returns over the relevant time period. The indications, however, are that hire charges have risen steeply, and that tractor owners have been the market leaders in setting charges. In 1972, for instance, the 4wt charge for land preparation was some Rs. 106/acre[1] which had risen to almost Rs.400/acre by maha 1979/80.[2] Charges for buffalo hire rose from some Rs.50 to Rs.200 over the same period. Given the additional requirement of labour for land preparation by buffalo as against the tractor requirement (estimated at an extra 8 man-days/acre for ploughing and 6 for mudding from data presented in Table 3.2.1), the extra cost of which will be some Rs.100-Rs.130, the total cost of land preparation by hired buffalo does not fall far short of the cost of performing the same operation by tractor.

These price movements hint at two tentative conclusions. The first is that tractor owners have been able to pass on rising fuel and capital costs to hirers, leaving themselves with substantial profit margins; the second, that buffalo owners have taken advantage of the increases in tractor hire

[1] Carr, 1975.

[2] Data from present study's survey data.

rates by raising their own charges well beyond what their increased operating costs would dictate. The relative cost advantage of hiring buffalo for land preparation has thus remained small throughout the period.[1]

In view of this comparatively static cost differential between the two alternative modes of land preparation, it is hardly surprising that our sample of farmers reported little change in the power source they used for land preparation in the five years prior to the survey period(Table 6.2.2).

Much further evidence is available to suggest that the farm power hire market is relatively static, and that there is little pressure for change. The great majority of owners and non-owners, for instance, reported that they had no difficulty in hiring their preferred power type during the three seasons immediately prior to the survey (Table 6.2.3). Of those who did experience difficulty, the power type sought was principally 4wt, though there were difficulties in hiring buffalo at Kaudulla. The reported problems of access to 4wt to some extent confirm our suggestions that the concentration of large units of draught power into fewer hands, in addition to its greater spatial concentration, would make access more difficult, especially for those located at the tail ends.

Again, few perceived the need to attempt to hire power from outside the study locations (Table 6.2.4), these being concentrated at Kaudulla where, as we have already indicated (Chapter 3) some hiring of tractors from the adjacent Minneriya scheme occurred.[2]

On the supply side, there was generally a high degree of satisfaction among owners with the amount of custom work available (Table 6.2.5). The level of dissatisfaction was higher at Uda Walawe and Padaviya than elsewhere, and was marginally stronger with the availability of transport than with agricultural work. These responses correspond with the estimated tillage capacities of the existing power stocks at the three study locations (Part 1 Report, p.54) there being an apparent surplus of farm power at Uda Walawe and Padaviya but not at Kaudulla.[3]

At all locations owners made minimal efforts to 'sell' their services to potential customers. The bulk of owners either hired to the same farmers season after season, or relied on non-owners to approach them with requests for hire (Table 6.2.6). A very small minority went out directly in search of work.[4]

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[1] Whilst the annual profits accruing to tractor operation remain substantial, they appear to be lower than those reported (53.5% p.a.) for a sample of 42 4wt drawn from Hambantota District (an area of atypically high charges) in 1973-74 - a time of low tractor populations, poor availability of spare parts (which made the working tractor population even lower), and restricted imports of such competing modes of transport as lorries (Harris, 1977).

[2] This low response may, however, be as much an indicator of the difficulty of establishing links with outside owners, the lack of confidence that they will travel the necessary distances to carry out the promised work, and the penalties of delay which might result, as of the lack of perceived need for such outside services.

[3] The high non-response rate for buffalo owners at Kaudulla reflects the predominant 'own use' of buffalo and lack of concern with the hire market (Part 1 Report, Table 2.1)

[4] This apparent lack of effort in searching for business is all the more surprising in view of the recent increase of some 10% in 4wt stocks at Padaviya under the TIMP. It indicates perhaps a confidence (in view of the low profits for 4wt at Padaviya reported in Chapter 5, an overconfidence) that capital costs can be recouped through increased hire charges.

TABLE 6.2.2: REPORTED CHANGES IN THE USE OF FARM POWER IN THE FIVE YEARS PRIOR TO SURVEY

Numbers reporting:	Padaviya	Kaudulla	Uda Walawe
1. No change	55	57	60
2. Change:			
from human to buffalo	–	–	2
from human to 2wt	–	–	1
from human to 4wt	–	–	2
from buffalo to 2wt	6	9	6
from buffalo to 4wt	7	4	3
from 2wt to buffalo	–	2	3
from 2wt to 4wt	2	–	1
from 4wt to buffalo	6	4	1
from 4wt to 2wt	4	1	1
Total reporting change	25	20	20

TABLE 6.2.3: WHETHER DIFFICULTY WAS EXPERIENCED IN OBTAINING THE PREFERRED POWER TYPE IN THE THREE SEASONS PRIOR TO SURVEY

	% Experiencing Difficulty	% Experiencing No Difficulty	No Response %	% of those Experiencing Difficulty Preferring Each Power Type		
				4wt.	2wt.	Buffalo
UDA WALAWE:						
Non-owners	13.9	64.6	21.5	63.6	18.2	18.2
Owners	9.7	69.4	21.0	33.3	16.7	50.0
KAUDULLA:						
Non-owners	30.1	43.8	26.0	43.5	4.4	52.2
Owners	13.8	65.5	20.7	87.5	0.0	12.5
PADAVIYA:						
Non-owners	10.0	85.0	5.0	87.5	5.0	12.5
Owners	6.6	92.1	1.3	100.0	0.0	0.0

TABLE 6.2.4: WHETHER THE SAMPLES PERCEIVED A NEED TO HIRE POWER FROM OUTSIDE THE STUDY LOCATIONS

	% Perceiving a need	% Perceiving no need	No response %
UDA WALAWE:			
Non-owners	0.0	79.7	20.3
Owners	0.0	79.0	21.0
KAUDULLA:			
Non-owners	11.2	64.8	24.0
Owners	19.0	62.1	18.9
PADAVIYA:			
Non-owners	1.3	93.7	5.0
Owners	1.3	94.7	4.0

TABLE 6.2.5: THE DEGREE OF SATISFACTION WITH DEMAND FOR CUSTOM SERVICES IN FIELD WORK AND TRANSPORT

	FIELD WORK						TRANSPORT					
	Expressing Satisfaction		Expressing Dissatisfaction		No Response		Expressing Satisfaction		Expressing Dissatisfaction		No Response	
	No.	% of Owners	No.	% of Owners	No.	% of Owners	No.	% of Owners	No.	% of Owners	No.	% of Owners
UDA WALAWE:												
4wt owners	12	60	8	40	0	0	10	50	9	45	1	5
2wt owners	14	48	9	31	6	21	14	48	7	24	8	28
Buffalo owners	13	57	2	9	8	34	-	-	-	-	-	-
KAUDULLA:												
4wt owners	13	76	0	0	4	24	10	59	1	6	6	35
2wt owners	11	65	0	0	6	35	7	41	1	6	9	53
Buffalo owners	8	20	0	0	32	80	-	-	-	-	-	-
PADAVIYA:												
4wt owners	26	79	7	21	0	0	14	42	12	36	7	22
2wt owners	13	57	7	30	3	13	11	48	9	39	3	12
Buffalo owners	17	65	7	27	2	8	-	-	-	-	-	-

TABLE 6.2.10: METHODS USED BY OWNERS IN SECURING CUSTOM SERVICES

No. of owners who:	Owners of: 4wt	2wt	Buffalo	All
UDA WALAWE:				
Go out to find customers	1	3	3	7
Find customers through friends & relatives	-	3	2	5
Hire to the same farmers every year	4	8	7	19
Wait for farmers to come to them	15	21	10	46
Other	-	-	-	-
KAUDULLA:				
Go out to find customers	4	-	-	4
Find customers through friends & relatives	-	1	-	1
Hire to the same farmers every year	3	-	-	3
Wait for farmers to come to them	10	8	1	19
Other	-	-	-	-
PADAVIYA:				
Go out to find customers	-	1	2	3
Find customers through friends & relatives	2	1	-	3
Hire to the same farmers every year	-	-	-	-
Wait for farmers to come to them	29	20	17	66
Other	-	1	-	1

TABLE 6.2.11: WHETHER THERE IS A PARTICULAR PART OF THE SCHEME IN WHICH OWNERS TRY TO OBTAIN FIELD WORK

Those responding:	Owners of: 4wt	2wt	Buffalo
UDA WALAWE:			
Yes	6	6	11
No	13	17	6
No response	1	1	1
KAUDULLA:			
Yes	7	1	-
No	7	7	-
No response	4	13	22
PADAVIYA:			
Yes	-	1	-
No	22	17	15
No response	10	4	4

TABLE 6.2.12: PERCENTAGES OF THOSE HIRING IN POWER WHO REGARD HIRING CHARGES AS FIXED OR VARIABLE

		Rates Perceived as Fixed	Perceived rates as variable and search for most favourable	No Response
UDA WALAWE:	Non-owners	12.5	33.3	54.2
	Owners	11.3	37.7	50.9
KAUDULLA:	Non-owners	66.7	8.0	25.3
	Owners	66.2	5.0	28.8
PADAVIYA:	Non-owners	56.4	43.6	0.0
	Owners	87.5	12.5	0.0

Once contacted, however, owners appeared to have little objection to working in different parts of the scheme. Few stated that they always attempted to find work in a particular sub-area of the scheme (Table 6.2.7).

Finally, both owners and non-owners were asked whether they regarded hire charges as generally fixed over a wide area, or sufficiently variable to make the search for a 'bargain' worthwhile. At Kaudulla and Padaviya, a majority of both groups saw the rates as fixed. The reverse applied at Uda Walawe, a discrepancy which we would regard as spurious in view of the high 'no response' rate, and the lack of any clear difference in market conditions there to account for the reversal (Table 6.2.8). When asked what main factors determined the level at which hire charges were set, the great majority of owners (70%) predictably enough referred to increases in running costs. Significantly, however, a small minority (7%) mentioned the existence of price-fixing agreements among owners. Similarly, earlier studies have indicated that whilst there may be substantial differences in hire rates among widely distant locations (ARTI, 1975) draught power owners have succeeded in applying a uniform charge within locations (Harris, 1977).[1]

To summarise, the functioning of the draught hire market appears, in the economic application of the term, to be highly imperfect. Whilst the large volumes of imported tractors following the 1977 trade liberalisation may have contributed strongly to a secular decline from the profit levels gained by tractor owners in the years of restricted availability of both tractors and spare parts in the early 1970s,[2] profits still remain substantial (Chapter 5), suggesting that efforts to pass on cost increases resulting from the fossel fuel crisit of 1973 to hirers have been largely successful. Buffalo owners have exploited the relative improvement in their competitive position by raising hire charges more severely than the rate of cost increase of their key maintenance input, viz. labour. Considerable barriers to the new ownership of either draught resource exist : even where credit for tractor purchase is obtainable, a deposit of at least 10% of the purchase price is payable, along with collateral guarantees. In the case of buffalo, during the course of our survey visits to Uda Walawe, we were repeatedly informed that threats of intimidation by owners of large buffalo herds discouraged non-owners from establishing herds of their own. Apart from such (possibly) localised barriers as these, nowhere in the Island does there exist a formal market[3] for the sale and purchase of buffaloes in working condition (c.f. also FAO, 1980). Lack of facilities for communication between potential buyers and sellers may thus result in the coexistence of unsatisfied demand for the purchase of draught animals[4] and the disposal of working animals for slaughter within the same locality.

[1] Burch (1980, p.335) has suggested, though without reference to hard data, that price competition is not a feature of the private tractor hire market.

[2] Of considerable further importance are the import restrictions in force on commercial vehicles at that time. These account for the high proportion of tractor time spent in the (highly profitable) business of transport reported by Harriss (1977) - 58% as against 38% across our entire sample (Table 6.2.1) (c.f. also Plumbe and Byrne, 1981).

[3] Nor, as far as the authors could ascertain, are there informal markets.

[4] Evidence of the existence of such a demand is provided by the fact that 23% of non-owners at Kaudulla expressed the intention to buy buffalo, against 4% for 2wt and none for 4wt. At Padaviya, however, the preference was for 2wt (14%), 4wt (5%) and buffalo (2%), whereas at Uda Walawe virtually no intentions to purchase any power type were detected. Apart from illustrating the continued demand for animal draught, these figures may be taken as an indicator at Kaudulla of the success of the system of tethering and feeding buffalo practised there.

It comes as little surprise to note the small proportion of hirers who switched their allegiance among power types within the five years prior to the survey.

An added source of inertia within the market lies in the difficulty that would-be hirers face in establishing contact with power owners. The onus of establishing contact falls by owners' default almost invariable on potential hirers. The channels of communication rely heavily on personal contact, with consequent penalties in time and expense for those non-owners located far from power sources (i.e. predominantly those living at the tail ends). Within this relatively static framework, both sides appear, however, reasonably satisfied with their lot - hirers complain of little difficulty in obtaining their preferred power type (although more difficulty with 4wt than with other types) and owners appear broadly satisfied with the available volume of custom work.

Superimposed on these numerous indications of the imperfect structure and sluggish functioning of the market for draught hire are the reported observations of owners and non-owners on price determination. Non-owners widely regard hire rates as fixed within a locality, and whilst the bulk of owners attribute hire charge increases to the rising costs of tractor operation, a minority explicitly recognised the influence of collusion among owners in setting hire charges.

6.3: The Scope for More Efficient Use of Draught Power

Outlined in the preceding section were numerous imperfections and inefficiencies in the markets for hire and ownership of draught power. To identify means of easing these constraints which have not already been tried and failed, or which appear impracticable from the outset, is a more difficult proposition. The more obvious non-candidate possibilities include:

(i) Publicly-owned tractors. The experience of government tractor pools in the 1950s was singularly unprofitable. Indications are that rates of charge were too low, but even at current market rates it seems unlikely that adequate profits will be made to outweigh losses attributable to the perennial problems of corruption and inefficiency.

(ii) Tractor pools owned by private consortia. The efforts to encourage private firms to hire out tractors for cultivation at below-market rates in 1967-70 failed, apparently through inability to meet costs at the rates imposed. It seems unlikely that such experiements could succeed in the future at below-market rates unless capital costs could also be spread over a high volume of non-farm work in the off-season.

Both of the above possibilities are particularly unattractive for the short/medium term, since they would probably involve an increase in the national tractor stock, whereas the priority for increased profitability lies in raising the use-efficiency of the existing stock, for which there is scope in both peak agricultural and off-peak seasons. A more promising possibility would be:

(iii) Drawing up a register of draught power owners with hire-capacity, and arranging farmers wishing to hire in tractors into contiguous blocks of land, preferably with some guaranteed payment scheme, so that a power unit can move quickly from one farm to another within a pre-

defined block, without the need to refuse services to those suspected of potential bad debts. Precisely such a system was used at Mahakandarawa[1] in maha 1980-81, but with mixed success and at the cost of enormous administrative effort: announcements over local radio succeeded in obtaining a hire-register of 65 owners of 4wt and 2wt; the Bank of Ceylon was persuaded to provide cultivation credit even to those farmers who had previously defaulted; payments were made direct to tractor owners on authentication by the farmer that work had been done satisfactorily. A rapid and early tilling was achieved, but difficulty was encountered in obtaining repayment of loans, especially by those who had suffered partial crop failure due to drought and could not obtain adequate compensation through the crop insurance scheme.[2]

Whilst improvement in efficiency can undoubtedly be achieved through direct manipulation of the markets in this way, much sustained effort is involved, frequently requiring drastic revisions to conventional working procedures in government departments. Whether this can be sustained for the long-term is an open question.[3] Certainly, the necessary effort would be more adequately repaid if benefits were to be obtained simultaneously through improved farming efficiency, such as might result from improved water management.[4]

Perhaps the essence of an easily-administered and self-sustaining strategy for obtaining improved benefit:cost ratios from the existing tractor fleet through increased use intensity is to be found at one of our study locations. At Uda Walawe, tractor use and profitability is higher than elsewhere: however, it is principally through non-agricultural work that this is achieved. Local paper and brick-making industries facilitate heavy tractor use for transport, so that capital costs can be spread over longer periods of use, and do not (as at Padaviya) fall almost entirely on the farmer hiring-in tractors. There are, of course, limits to the extent to which industries requiring large volumes of transport can be decentralised. The indications are, however, that mechanisation policy in the last three decades has concentrated exclusively on the use of tractors in agriculture: strategies for increasing their off-peak use in transport have not been formulated, not because such opportunities cannot be increased, but primarily because they have not been perceived as necessary. The assumption always appears to have been that a higher benefit results from tractor use in agriculture than in non-agricultural work; yet the (admittedly crude) calculations in Chapter 6.1 indicate that the reverse is true. Furthermore,

[1] One of the 5 Tanks under the TIMP.

[2] TIMP - Mahakandarawa Early Sowing - Interim Report. Anuradhapura, 18.9.80 (mimeo) and Long, M. T., (Personal communication). Other difficulties included the poor quality of work, no doubt encouraged by the fact that (a) the farmer was not paying directly for cultivation and (b) that it would take a great deal of courage for a farmer to raise a complaint against such a powerful member of the local community as a tractor owner .

[3] Such revisions can, as was the case at the TIMP, most easily be achieved through the efforts of expatriate advisers. Needless to say, the continuity of effort cannot therefore by guaranteed.

[4] As was the case at the TIMP. See Chapter 6.4.

it may well be that the marginal benefits to increased transport use are greater than to increased use in agriculture without substantial improvement in water-control practices in major irrigation. Prospects for increased off-season use include that of locating the large-scale milling and storage of paddy closer to the centres of production, thus providing the opportunity for tractors to participate more actively in the short-haul transport which would be involved.[1] Similarly, consideration could be given to keeping officially-owned tractors to a minimum in major irrigation schemes, and relying increasingly on private hire contracts for construction work.

In any attempt to provide increased transport opportunities for tractors it is imperative that the possibility of fresh imports of tractors for these opportunities be restricted: the use-levels and profitability of the existing fleet cannot be increased if new work opportunities generate a corresponding increase in tractor imports.

The prospects for increased efficiency of tractor use in agriculture, and simultaneously of agricultural production have been alluded to briefly above. The control mechanism linking the two activities is the potential of tractors for increasing the efficiency of water use. The prospects in this area are so complex as to merit separate discussion in Chapter 6.4.

6.4: Interactions Between the Use of Farm Power and Water Use in Major Irrigation Schemes: Future Prospects.[2]

The relationship between farm power and irrigation water - two of the major inputs into agricultural production in the Dry Zone - is necessarily complex. They are complementary inputs, but in some degree and in some contexts the one may be substitutable for the other. The precise pattern of their interaction varies from locality to locality according to such factors as: the characteristics of the soil and the climate; the extent, type and ownership distribution of farm power stocks; the cultivation practices to which farmers are habituated; the patterns of irrigation water availability; and the extent and type of control which is exercised over the use of this water. That said, it is clear that, among major Dry Zone irrigation schemes, the degree of variation found in these factors is rather limited. There is a great deal which we can say which is applicable to all or to most schemes.

It is similarly rather clear that there is at present no prospect of any major change in the pattern of interaction between farm power and irrigation water. It is possible and convenient to assume the present situation to be more or less static, and to examine separately three sets of possible factors which might change the pattern of farm power - water use interactions: first, changes in price ratios; second, the availability of new techniques; and third, administrative action to change water use and agricultural practices. This ordering approximately represents decreasing degrees of likelihood and increasing degrees of deliberate government intervention.

6.4.1: Changes in price ratios

Almost any change in the ratios of agricultural input and output prices is likely to have some implications for the farm power-water use relationship. There is however little point in speculating about all possibilities,

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[1] See Harriss, B. (1978).

[2] Much of this section is attributable to M. P. Moore (IDS, University of Sussex) consultant to the Farm Power Study on Water Management.

and one can with some confidence assume that certain prices are unlikely to change very much. For example, the current rate of new job creation is not so high that we can expect any very drastic increase in agricultural wage rates - and thus the cost of labour - in the Dry Zone in the foreseeable future. Similarly, since for both political and technical reasons it will remain impossible to levy charges on amounts of irrigation water actually used by farmers, water will remain a free good to them.

One price more likely to change is that of tractor power. While current local and world economic trends do not suggest that the cost to the tractor owner/farmer of tractor power is likely to fall relative to other costs, there is at least a fair chance that it will increase further. International trends and Sri Lanka's balance of payments might separately or jointly bring this about. The consequences depend to a large extent on (a) how far draught animal hire charges are raised in response (the typical short term reaction is to raise buffalo hire charges in line with tractor charge increases - see Chapter 6.2), thus making all farm power more expensive; and (b) how far in the longer term there is a shift to animal draught. The general effect of an increase in tractor charges in the absence of more deliberate steps to improve the joint efficiency use-patterns of power and water (see below), will be a tendency to increase the quantities of water required for weed control, thus reducing the area which can be effectively irrigated. Tractor land preparation is likely to be less thorough if tractors become more expensive, thus necessitating more weed control at later stages. Any greater dependency on draught animals which may accompany an increase in tractor charges will discourage a shift from water-using mud-land preparation to semi-dry land preparation, but, as we have argued elsewhere (Chapter 6.2 and Appendix 3.4) it is unlikely to increase the demand for water under present water management conditions.

One other set of price ratios which are likely to change are the output prices of paddy versus non-paddy crops. Whether or not they do change depends above all on import policies: on the tariffs or quotas placed on the imports of competing products - rice and wheat flour in the case of paddy, and in the case of the other crops, directly competitive imports of onions, chillies, vegetables, pulses, gram, soyabeans, etc. There may be some partial reversion to the very high levels of protection against competitive imports given to producers of these 'subsidiary food crops' in the period 1968-77. Even if there is no change in price ratios one can expect a further development of the existing slow trend - too slow for the likes of policy makers - whereby, as marketing channels and tastes become established and cultivation practices become tried and tested, farmers become more willing to grow subsidiary food crops rather than paddy on irrigated land in the yala season.

There are a number of very good reasons - not evidently always appreciated by officials - why farmers should be reluctant to rush wholesale into the cultivation of non-paddy crops in the yala season despite tales of the great wealth this can bring:-

1) The initial per acre cash cost is much higher than for paddy, making this difficult for all but the wealthier farmer.
2) Market outlets for non-paddy crops are often poorly developed, and producer prices unpredictable.
3) The techniques of cultivation, notably the need for land ridging, precise plant spacing, good drainage and chemical or hand weeding, are very different from either paddy or chena ('slash and burn') cultivation, and thus require gradual learning and experiment. Failures are common.

4) Decisions about irrigation water issues in yala, announced at the pre-seasonal water meeting, may leave little time to organise the credit and seed required for non-paddy crops. Further, these 'decisions' are not authoritative, and farmers often have little confidence either that water restrictions will be severe enough to prevent cultivation of a paddy crop or that, if they grow non-paddy crops, they can be sure to receive enough water throughout the season to protect the heavy investment involved.

In the absence of any major change in the environment affecting farmer decision making, there is unlikely to be a major shift towards non-paddy crops in the yala season. However, on a very limited basis such a shift seems to be taking place, and it has implications for the use of farm power and irrigation water.

The implications for water use of cultivating non-paddy crops in yala are quite clear and welcome. Far less water is required for each rupee's worth of output than in the case of paddy. Not only is the general irrigation requirement much lower, but since the land is prepared in a semi-wetted condition, the water requirement for tillage is far less than in the case of paddy. The power requirement both in total and by type is rather more difficult to estimate, for it depends on a number of factors on which numerical estimates cannot easily be placed.

The per-acre power requirement for non-paddy crops is probably somewhat lower than for paddy. There is no power requirement for threshing, and land for non-paddy crops may be prepared by a single ploughing followed by manual construction of raised beds and furrows. (Wider cultivation of non-paddy crops could however lead to the introduction of animal and tractor drawn implements for ridging and furrowing).

Compared to paddy, non-paddy yala cropping involves an extension of the acreage cropped and, less certainly, reduced power requirements per acre. The change in the aggregate power requirement cannot be predicted, although the value of output per unit of power input should increase. Non-paddy yala cropping thus promises to lead to more efficient use of both irrigation water and farm power. For two reasons we might assume that the advantages of owning and using 2wt and buffaloes relative to those of 4wt might increase with a shift from the cultivation of paddy to non-paddy crops. The first is that there is no threshing requirement for non-paddy crops, and threshing is the one single operation at which 4-wheeled tractors are clearly preferred over other power sources (see Chapter 3). The relative advantages of owning 4wt will thus be lessened. The second reason is that the high labour input required to prepare land for non-paddy crops, especially for the construction of beds and ridges, is likely to result in pressure on labour supplies early in the yala season, with a consequent preference for preparing small plots of land on a staggered basis over several weeks - a practice which fits in with the varying durations of non-paddy crops. Early access to power to prepare <u>some</u> land, especially for chillies, will become important. Yet the transaction and transport expenses incurred will militate against any tendency to hire in power on a piecemeal basis to prepare one piece of land at a time. Instead, there is likely to be a shift of preferences in favour of own-power rather than hiring in, and thus for draught animals and 2wt rather than 4wt.

Since for reasons given above one cannot expect any dramatic switch to non-paddy crops in the yala season in irrigation schemes, it is unlikely that there will from this source be any major shift in power use preferences or use patterns over the next ten years or so.

6.4.2: The availability of new technologies

1) Minimum and zero tillage

After an extensive programme of research and field trials in West Africe, the International Institute for Tropical Agriculture established a 'No-till' project in Sri Lanka with field work based at the Maha Illuppallama Dry Zone Research Station.

The main objective of the programme of research and field trials is to evolve tillage systems to replace shifting cultivation which are are both economically attractive and sustainable under continuous cropping without excessive soil erosion, depletion of fertility and weed competition.

The techniques under assessment involve the extensive use of mulches derived from the residues of the previous crop, from weed cover to which herbicide has been applied or from specially planted leguminous avenue crops from which are obtained firewood, cattle fodder and a weed-suppressing mulch. Specifically-developed injection planters then penetrate the mulch for seed placement.

It is claimed that mulching reduces soil erosion to only 2% of what would occur on 10% slopes under conventional ploughing, and suppresses weed growth to the extent that only a single application of post-emergent herbicide will suffice for adequate weed control. The use of leguminous mulches will, additionally, contribute to soil fertility through nitrogen fixation and may provide an edible crop from the mulch itself (e.g. in the case of winged bean)(Wijewardene, 1980).

For upland farming, a variation is provided by 'avenue cropping', developed from agro-forestry techniques, which involves the systematic cultivation of leguminous tree crops such as Leucaena or Gliricidia in rows some 7' apart. At the start of the farming season these are lopped to some 2' height, and their leaf mulch left on the soil between rows through which seasonal crops are then injection-planted. Woody material from the prunings can be extracted for domestic firewood.

The development of zero tillage techniques for application to irrigated lowland paddy production seems likely to involve problems of a different order from those encountered in upland farming. From the onset of the monsoon, the (sometimes temporary) impounding of rainwater into paddy fields - especially in the poorly-drained areas - may impede the effectiveness of herbicide applications. Similarly, the incidence of aquatic weeds may require more complex and expensive herbicide regimes. The use of mulches is likely to be of limited value in conditions where flooding cannot be avoided, and, without an injection planter capable of performing under wet or dry conditions, would impair the planting of paddy.

Zero tillage would almost certainly require the lowland farmer to treat his paddy as an upland crop in the early stages, using herbicides to obtain a pre-planting knockdown of weeds, and planting under dry conditions with an (as yet unproven) injection planter. Under conditions in which paddy fields can be adequately drained to permit this sequence of operations, the difficulties are reduced. Some fields, however, are difficult to drain even in the poorest of monsoons (e.g. large areas of the lower parts of Tract 1 and Tract 8 at Kaudulla

Stage I). Others are badly flooded in years of heavy monsoon rain, but not in others. We suspect that the farmers' inability to switch at short notice from dry to wet tillage conditions would impair the acceptability of 'no-till' techniques. Furthermore, those lands which are prone to flooding after dry planting would require the rice plant to adapt from aerobic to anaerobic root systems, with consequent yield reductions. In paddy areas involving few cultivators (such as minor irrigation schemes) it should not be difficult for agreement to be reached on the universal and synchronised adoption of a single set of techniques such as those developed under zero tillage (though, even here, farmers' preferences may vary across the soil cataena, reflecting drainage conditions). In major irrigation, involving several thousand farming families, the adoption of a single novel set of techniques by all farmers simultaneously seems improbable. If adoption were not simultaneous, water would continue to flow through the channels to supply it to those practising wet cultivation, with little overall saving in water consumption and additional problems of poor drainage for those wishing to practise dry cultivation but whose fields are affected by seepage from channels.

Although data produced by the IITA/Sri Lanka Project indicate a potential cost saving of some Rs.170/acre under zero tillage compared with conventional ploughing systems (IITA/Sri lanka, 1980) for the reasons advanced above we doubt whether there is any short or medium term prospect of widespread adoption of zero tillage on major irrigation schemes. In addition to the difficulties specific to lowland irrigation cultivation that we have mentioned, there remain the more general problems of farmer training in the mixing of precise quantities of herbicide, and in the techniques and timing of ultra-low volume or controlled droplet application. Repeated casual observations by our study team suggest that herbicide application is currently haphazard in timing and method, and much higher standards would be necessary for the success of zero tillage.

2) New paddy varieties

A major single proximate cause of low paddy yields or even complete crop failure in the Dry Zone is competition from weeds. It is farmers' perpetual concern about weeds which above all lies behind their preference for using lavish quantities of irrigation water. Paddy varieties are therefore naturally selected for their ability to overcome weed competition through height, rapid, early growth, or widespreading leafcanopy (to shade weeds). High yielding paddy varieties are all relatively short and therefore lose some potential advantage over weeds. They need not however necessarily be more vulnerable. H4, a Sri Lanka-bred variety now classified as an 'old high-yielding variety' is relatively well able to deal with weeds by spreading a wide leaf canopy. It is however of $4\frac{1}{2}$ months duration, and there is no comparable short duration ($3\frac{1}{2}$ months) variety. One strategy to improve water and power use efficiency - early and semi-dry land preparation and sowing in maha followed by an early yala crop - is in part dependent on a short maha season. For this increases the availability of water for a yala crop by (a) reducing the period of water issue required in maha and (b) minimising the overlap between the yala season and the period of high irrigation water loss through high evapotranspiration in the middle of the calendar year (see below). Early and semi-dry land preparation and sowing however puts an increased premium on the ability of the paddy plant to compete with weeds. The absence of a paddy variety which is

both of short duration and robust in the face of weed competition is thus a constraint to the adoption of the early-sowing strategy, which is discussed in more detail below. If current research at Maha Illupallama Research Station and the Central Rice Breeding Institute succeeds in producing a suitable paddy variety, the early sowing strategy will be that much more feasible and attractive.

6.4.3: Administrative action to change water use and agricultural practices

(1) Improved water management

Policies and practices for the better management of irrigation water are not in themselves the main focus of this report. Water management is a major topic in its own right, and has been tackled elsewhere by members of the research team (see Part 1 Report, Chapter 3.4; Moore, 1980a). It is however important to record that, even were policies towards farm power to remain unchanged, more efficient water use would in itself increas the efficiency of the use of the farm power stock without requiring a high proportion of tractors in the stock. A more reliable and predictable supply of irrigation water would allow and encourage farmers to put more effort and more inputs (fertiliser, labour, etc.) into production, and thus lead to higher output and higher returns per unit of all inputs used, including farm power. Insofar as better water management were to save water in the maha season and thus permit the extension of the cultivated acreage in the yala season, this would provide greater opportunities for the use of farm power stocks which are currently unemployed or under-employed at that time (c.f. Chapter 6.2. above). This would permit annual use-intensities to increase from the present low level. The more intensive use of capital assets (i.e. tractors) thus implied would permit either more rapid recoupment of capital outlay at existing profit margins per hour of use, with the prospect of faster re-investment of the surpluses generated, or a reduction in hourly charges and recoupment of capital outlay at the same rate, with a consequent shift in the terms of trade to the advantage of (economically vulnerable) non-owners of draught power, or some combination of the two. Furthermore, any such increase in the demand for farm power which is not seasonally concentrated will tend to increase the returns to and thus the attractions of owning those types of farm power which (a) have few or no alternative uses outside agriculture, and (b) tend to deteriorate more according to age rather than to cumulative use rates. In other words, yala cropping will increase the attractiveness of owning buffaloes rather than tractors, and 2wt rather than 4wt.

It is rather outside the scope of this report to discuss in any detail the ways in which standards of water management might feasibly be improved. It is useful however to provide an illustrative example. The research which has been conducted on the Kaudulla scheme since 1978 by the UK Hydraulics Research Station and the Sri Lanka Irrigation Department has revealed that a considerable quantity of water could be saved in the maha season if irrigation water were to be issued only when rainfall was inadequate. Because water management at present is not sufficiently sensitive to reduce irrigation issues where rain has occurred, most rainfall is lost as run-off. To save rainfall is not possible without the investment of certain resources and efforts, for

[1] Holmes, D. W. et al (1980) "Water Management Study at Kaudulla Irrigation Scheme, Sri Lanka, II - Interim Report Covering Seasons Yala, 1978 to Maha 1979/80", Hydraulics Research Station, Wallingford, September, 1980.

it would otherwise be standard practice. A major point to consider is the evidence produced in the same study of the enormous local variability of rainfall even on a scheme covering only some eleven thousand acres of paddy land. This is a product of the shower pattern of the monsoon rains. The present practice of closing the main sluices from the tank when it rains hard there is a very inadequate and possibly counterproductive method of attempting to adjust for rainfall. It may deprive of water those areas which have received no rain at all, especially if they happen to be at the tail end of the scheme. For, since no control is exercised over the level of water in the main channel, this falls as soon as the head sluice is closed. Even after the head sluice is re-opened it may take several days before the main channel is sufficiently full for water to be pushed down to the tail ends of the main and distributory channels.

To save rainfall efficiently and without damaging crops in some areas would require, from the physical and procedural point of view: operational procedures for the water level in the main channels to be kept constant at all times to make possible rapid and effective responses to local water requirements; the existence and use of cross-regulators in the main channels and efficient gates from main channels to distributory channels; an effective system for reporting regularly and rapidly on rainfall and crop conditions on a tract by tract basis; and a procedure for utilising this information. In essence, what is required is more informed control of water; this is necessary whatever the precise techniques of water management chosen.

Apart from the inadequacy of the physical infrastructure on many schemes, there are pre-conditions to the adoption of such water-saving procedures which are organisational and attitudinal, and still in large part unfulfilled. They include recognition that low water use efficiency is more the result of the lack of (or mis-)management of the irrigation system rather than of poor water use practices by farmers at field level; acceptance that irrigation management is about the control of water after it has left the main sluice; the creation of a climate of sufficient trust between farmers and water managers that the former will be prepared to accept the enforcement of rotations and limits on water use without resort to political pressure or to damaging the physical infrastructure.

The reaping of the high potential benefits to improved water management[1] thus requires action on several fronts: in the conception of what water management is; in the effective representation of farmers in decision-making; in farm organisation; in physical rehabilitation; in the creation of effective communication systems, procedure and discipline within management organisations; and in the psychological climate at field level on irrigation schemes.[2] Because of the complexity of the interaction between these factors and the importance of such unpredictable variables as attitudinal and organisational change, it is not possible to predict likely future rates of progress. The

[1]For example, the preliminary estimates of the Kaudulla study, covering four seasons beginning yala, 1978, are that each year actual water issues are 33,600 acre-feet in excess of computed minimum requirements (see D. W. Holmes, et al, op. cit.). If one values this water at the estimated current cost of providing new irrigation water - Rs.300 per acre-foot (P.Russell, private communication) - then the cost of the water wasted on this scheme amounts to Rs.10 million per year, or about Rs.500 for each acre of land irrigated.

[2]See, for example, Moore (1980a).

progress which has been registered in recent years has largely been in the recognition of the nature and magnitude of the problem. Few, if any, concrete improvements in water use efficiency appear to have been achieved outside one or two intensive pilot schemes (c.f. Moore, 1980a). However, having recognised the problem Sri Lanka is in a better position than it was a few years ago to tackle it. There are encouraging signs that water management is becoming a focus of attention in the Agriculture and Agrarian Services Departments. These, alongside the Mahaweli Authority, are beginning to provide what may prove very stimulating competition in water management to the department 'traditionally' concerned with this subject - the Irrigation Department. It is therefore possible to be cautiously optimistic about the possibilities of progress.

(2) The organised staggering of cultivation

The 'staggering' of cultivation within a single irrigation scheme - i.e. wide differences between different plots and farmers in the timing of land preparation and sowing - has been the subject of much complaint, has often been attributed to a scarcity of farm power, and has thus been used as evidence of a need to increase power stocks, especially via tractor imports. We have already discussed at length the rigidities in official planning which equate draught power shortages with inadequate numbers of power units and not with low use levels of the existing stock (Part 1 Report, Appendix V). This is a particularly serious misconception in view of the demonstrably low use levels of the farm power stock (Chapter 6.2, above). In the body of this report, we have, in any case, demonstrated that the major cause of reduced water use efficiency is through a delayed start to the season by the bulk of farmers. Once the decision to start cultivation has been made, the degree of staggering among our samples has not been severe (Appendix 5 and Figures 3.1-3.3) - some 6-8 weeks being necessary to complete land preparation and achieve full crop establishment, which compares closely with independent observations for Minneriya, Kaudulla and Mahaweli System H by the IDRC/IRRI/Sri Lanka Cropping Systems Project (personal communication) in maha 1978-79. Even under full mudland cultivation it should, however, be possible to plant within four weeks of starting cultivation. There is thus some scope for reducing even this moderate level of staggering. It is especially surprising that, to the best of our knowledge, no attempt has ever been made to organise staggered cultivation in such a way as to make better use of the farm power stock. Such a practice should in fact be relatively easy to implement given the physical shape of most of Sri Lanka's large irrigation projects. The typical scheme comprises a bund across a shallow valley, and two main channels running down one each side of the valley.[1] In most cases each is served by a separate sluice in the tank bund - the argument below is however equally valid in cases where the two main channels diverge below the sluice outlet. It would seem quite feasible that, at the beginning of the season, water should be issued to one main channel some time - say, two weeks - before the other. This should permit owners of farm power to concentrate first on one locality and then the other, extending the amount of work done by each unit and thus reducing the overall number of units required.

There are of course potential obstacles to such a plan. Farmers would need to see the rationale and to approve. Arrangements would perhaps have to be made to change from year to year the turn to cultivate first, although this might not be feasible where the sluices are not at the same level, for then only the farmers served by the lowest sluice can draw on the last few

[1] See Map Appendix 8.

inches of water in the tank at the end of the year. Where there is only one main channel the same principle could be pursued by staggering between tracts, although this might be physically more difficult to enforce.

It is however, difficult to see any objection to attempting such a practice, at least on an experimental basis, on most schemes. There is some evidence that the current authors' earlier advocacy (Part 1 Report) of this practice has gained some sympathetic hearing. The potential advantages appear especially great in the light of the evidence that hire markets for farm power are very imperfect, and characterised by lack of information on the part of owners about potential contractees, and vice versa (see Chapter 6.2). It is important to note that there is nothing automatic about markets. In general they work best where there is either (a) a physical market, such as a village fair, where buyers and sellers come into physical proximity and can see what is being offered and demanded; or (b) where there is an institutional market, like the cinnamon market in Colombo, where a number of dealers and exporters are known to one another and have means of communicating quickly. In the case of farm power there is neither a physical nor an institutional market. Hiring for agricultural purposes takes place principally during a few relatively brief periods in the year. The individual owner may change the stock of units he has for hire from one season to the next. Shortages of information and the constraints on and costs of spatial movement contribute to the inefficient performance of the market.

It follows that (a) the sequential concentration of demand for farm power hire in one locality after another should in itself help to make the market run a little more smoothly; and (b) that there is a good case in principle for some kind of public action to increase communication between potential hirers and potential contractees. This might, for example, take the form of a public register, renewable daily, of those with power for hire and those seeking it. This could form a very useful complement to the practice of organised staggering of cultivation.

Some approximate calculations permit the broad order of magnitude of benefits derivable from a reduction in staggering to be assessed. Estimates derived from Murray-Rust and Cramer (1979) indicate that issues during the continuous flow of water given for land preparation in yala 1979 at Minneriya and Kaudulla were 0.39 acre-feet/acre and 0.26 acre-feet/acre per week respectively (measured as issues at the headworks). The continuous issue for land preparation is of varying duration, depending on such local conditions as rainfall. At Mahaweli System H, Minneriya and Kaudulla in maha 1978-79 it lasted for 4½ weeks (IDRC/IRRI/Sri Lanka Cropping Systems Project - personal communication); at Padaviya in the same season it ran for only 4 weeks (letter of Irrigation Engineer of 15.12.78,op. cit.). During this particular season it may, however, have been atypically short because of the cyclonic rains in late November, 1978. For yala, 1979, the continuous issue lasted 7 weeks (Murray-Rust and Cramer, op. cit.). The typically lower rainfall in yala compared with maha may require on average a longer duration of continuous issue. If we assume 0.3 acre-feet/acre of water per week of continuous issue, lasting typically 5 weeks in maha and 7 weeks in yala, the consumption of irrigation water (principally) for land preparation amounts to approximately 1.5 acre-feet/acre in maha and 2.1 in yala. Given, at Kaudulla, water issues (at the head works) of 4.18 and 4.09 acre-feet/acre in maha 1978-79 and 4.27 and 4.49 in yala 1978 and 1979 respectively (Holmes et al, 1980), the issue intended for land preparation amounts to approximately 36% of the total

issue in maha and 48% in yala.[1] If the continuous issue of water for land preparation could be reduced by one week from its typical duration of 5 and 7 weeks in maha and yala respectively, at a total consumption of 5 acre-feet/acre in maha and 8 acre-feet/acre in yala for the season as a whole and 0.3 acre-feet/acre per week for land preparation, an acreage expansion of 6.1% in maha and 3.8% in yala would be possible (ignoring the impact of evaporation losses of storing the saved water over the season). On a scheme of some 10,000 acres of paddy this would provide 640 additional acres in the maha - or a livelihood for some 250 additional settler families. Multiplied over Dry Zone irrigation as a whole, it would allow extra irrigation of some 38,000 acres or settlement of 15,000 additional families - in other words equivalent to the establishment of 3 further schemes of the current size of Padaviya.

A simple example illustrates that a water saving of this order should be feasible with only a 2-week staggering and without any higher tractor use intensity. Consider an 8,000 acre scheme with 80 tractors where land preparation typically takes 5 weeks, involving a work rate of 20 acres/tractor/week. Dividing the scheme (and tractor population) into two equal parts (A and B), staggering by two weeks and reducing the land preparation period for each half from 5 to 4 weeks would have the following effect: The first side (say A) to receive water would have the attention of all 80 tractors for the first fortnight, the 80 would split between the two halves for the second fortnight, and then concentrate on side B for the final fortnight, giving a total of 480 tractor weeks of work over the 3 fortnights, and a reduced work intensity of 16.7 acres/tractor/week necessary to complete the whole 8,000 acres. Given the low current use level of tractors,[2] and the scope for official assistance in facilitating hire contracts, an increase of this order appears feasible.

(3) <u>The promotion of early land preparation and sowing</u>[3]

<u>The Concept</u>. There has in recent years been a considerable degree of interest, at the level of both research and experimental action projects, in the idea of advancing the cultivation calendar in Dry Zone irrigation projects. Experimental action projects have been undertaken both on village tanks (the work at Walgambahuwa Tank of the Cropping Systems Research Project at Maha Illupallama Research Station) and on large schemes (the Tank Irrigation Modernisation Project on five tanks in the North-Central and Northern Provinces). The core notions behind these experiments are:-

(i) That at present a great deal of valuable irrigation water and rainfall is wasted by the standard practices on irrigation schemes of delaying land preparation until the tank is full or nearly full, using lavish

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[1] By comparison with data from a number of other major schemes, the Kaudulla figures however appear low. Typically 5 acre-feet/acre in maha and 8 in yala are used (Irrigation Department - personal communication). Even at these higher figures, the proportion issued for land preparation remains at 25-30% of the seasonal issue.

[2] The analysis of reasons given by owners for the non-use of their tractors in Appendix 6.4 indicates the extent of under-utilisation at peak periods.

[3] This section owes a great deal to valuable conversation with staff on the Tank Irrigation Modernisation Project, papers they have supplied, and field observations of their project. The TIMP staff are however not responsible for the interpretation put forward here, and may indeed disagree with aspects of it.

quantities of water for wet land preparation and generally failing to use rainfall as a substitute for stored tank water either for land preparation or during crop growth.

(ii) That the area cultivated, total agricultural production and production per unit of scarce irrigation water could all be considerably increased through a modified set of agricultural and irrigation practices involving:

a) the early preparation (ploughing) of land in a semi-dry condition at the onset of pre-maha rain showers in September;
b) the sowing of the rice crops in October on semi-dry land, using only rainfall and not irrigation water;
c) the use during the maha season of only the minimal quantities of water required to meet moisture deficiencies arising from inadequate rainfall;
d) saving the bulk of stored irrigation water to make possible a large yala crop, either of irrigated paddy or lightly irrigated non-paddy crops;
e) the reliance on herbicides for weed control instead of maintaining a minimum depth of standing water.

Within this general strategy there are a number of elements which may be varied. Some are discussed in more detail below. Those which are not further discussed[1] include:-

a) The question of the duration of the paddy variety chosen for the maha season. The potential advantages of the strategy can best be reaped if a short duration variety is chosen. Not only does this reduce the period over which irrigation water might be required in the maha season, but it also makes possible an early yala season, and thus minimises the loss of irrigation water which otherwise occurs when the season coincides with the month of high evapotranspiration rates in June to August. However, the paddy variety chosen for the maha season must additionally be able to overcome strong weed competition (see below). At present there is no suitable high yielding paddy variety which is both of short duration ($3\frac{1}{2}$ months) and robust in the face of weed competition (see above).

b) The question of whether the early sown maha paddy be broadcast or line sown. At present broadcasting is likely to be the only popular otpion.

c) The question of whether it is desirable for farmers to be encouraged to use little or no fertiliser in the maha season, when much of it may be washed away, and to save resources for a high input, high output yala of paddy or non-paddy crops.

Early Land Preparation and Farm Power. As it has been tested and promoted on the large scale irrigation schemes under the Tank Irrigation Modernisation Project (TIMP) the technique of early land preparation and sowing has become associated with a strategy of tractorisation, especially the use of 4wt, although proponents of the technique recognise that some role remains for other power types.

Inadequacy of farm power was identified as a constraint on early and speedy land preparation and an initial component of the project was the supply of additional tractors (Chapter 2.4 above). It has been argued by the TIMP staff that early dry or semi-dry land preparation cannot be

[1] Although clearly they have implications for agronomic and agricultural engineering research.

completed without prime reliance on 4wt because of the speed at which they operate. It has further been convincingly argued that (a) 4wt are more efficiently used in semi-dry land preparation than in mudland preparation, for in the latter case they suffer wheel-slip, require more fuel per acre, and deteriorate more quickly; and (b) that the relative economic efficiency of 4wt vis-a-vis draught animals (and 2wt) is greater in semi-dry tillage than in 'mudding'.

These points collectively appear to highlight two very divergent land, water and power use strategies on large irrigation schemes: the one (TIMP) involving greater use of 4wt to increase cropped area output and water use efficiency; and the other ('mudding' and later land preparation) involving greater reliance on animal power at the possible cost of a lower cropped area, total output and output per unit of irrigation water. If the difference between the strategies were so clear, we could proceed straight to examining data relevant to the choice between them: their relative practical feasibility, and relative socio-economic benefit:cost ratios. Unfortunately, the difference between the two strategies may not necessarily be quite so clear as the above summary would suggest.

As it has been so far promoted, the TIMP strategy involves the ploughing of land on the onset of the pre-monsoonal showers in September. The land should be sown before the end of October. Before the onset of the pre-monsoon showers the soil will be too hard to plough, or at least to plough efficiently and economically by 4wt, and perhaps almost impossible to plough by buffalo or 2wt. If there has been a yala crop the soil will be bare, exposed and hardened for a month or two, or if there has been no yala crop, for up to six months. However, as the TIMP staff have themselves suggested, the initial tilling need not be immediately before the maha crop but at the end of the yala crop, thus benefitting from moisture remaining in the soil. This would be all the more feasible if the yala crop had been a paddy crop, and therefore relatively heavily irrigated, for there would be more residual moisture.

The major attraction in principle of tilling after the yala crop on residual moisture is that this would spread the tilling operation out over time. There would no longer be such a strong imperative to invest in 4wt in order to complete pre-season tillage in a brief period in September and early October. At that point it should be possible to complete a second and final tilling on residual moisture: it promises to conserve rainfall to make the early pre-maha rains more effective. For at present it is common that in the more clayey soils very deep fissures open up during the period when there is no crop. Early rainfall tends to go to fill these fissures and thus not to be effectively available to soften the top soil for early tillage. If tilled after the yala crop clay soils would be less prone to cracking, and early rainfall would thus be more effective.

As will become clear below, there are obstacles to the adoption of tillage on residual moisture certainly no less severe than the obstacles to the adoption of early tillage/sowing more generally. They relate above all to risk, to farmers' unwillingness to pursue the practice in the absence of any guarantee or confidence that others will do the same, and to the problem of obtaining finance in time. And, since tillage on residual moisture has not been heavily promoted like tillage on early pre-maha rains, one can be even less certain of its technical feasibility, benefits and attractiveness to the farmers. Therefore, for the purpose of the discussion below of benefit:cost ratios of the different strategies, it will be assumed that

early tillage means simply tillage on pre-maha rains, and that this will create a pressure for rapid land preparation and therefore for 4wt. This assumption is employed only to help clarify the somewhat complex issues involved in evaluating these alternative strategies. It is not intended to imply that the strategy of tillage on residual moisture can or should be ignored. On the contrary, it would seem to require more rigorous investigation and experiment.

The Practical Feasibility of Early Sowing. Early land preparation and sowing - "Kekulan" in Sinhalese - is not a new concept for Dry Zone farmers. Even on irrigation schemes it is regularly practised on highlands which do not receive irrigation water and by farmers on the tail ends of schemes who have little faith that irrigation water will actually reach them (c.f. the discussion of the timing of cultivation at the tail ends in Chapter 3.4). It is in fact a 'traditional' practice which has been partly supplanted by the introduction of large scale irrigation. Ignorance of kekulan is no major barrier to its adoption. To see what those barriers are it is useful to look first at some of the advantages of the usual practice of delayed mudland preparation. From the farmers' point of view there are two main advantages of established practice:-

a) Delaying land preparation until there is a large volume of water in the tank guarantees some kind of crop and thus provides insurance against the loss of the resources invested in land preparation and sowing.
b) The practice of mud-land preparation and the use of large quantities of irrigation water provides what is to the farmer (if not necessarily to the national economy) the easiest, cheapest and most reliable protection against a major cause of poor paddy yield: weed competition.

There are three further advantages to conventional practices accruing to those responsible for organising supporting services:-

i) By beginning to issue water only when the irrigation tank is well stocked, those responsible for water issues (irrigation staff and the Government Agent) are secure, at least in the maha season, against irrigation water scarcities and thus against the need to enforce physically and politically troublesome and difficult tight institutional water issue schedules (c f. Appendix 3.4).
ii) Decisions about the timing of agricultural credit advances and the varieties of paddy seed to be supplied can continue to be made, with minimal effort, in the 'water meeting' held a few weeks before the season commences.
iii) Where a crop is fully irrigated the basis of indemnity under the national crop insurance scheme is clear. If a partial reliance on rainfall is introduced, the responsibility for yield losses resulting from water stress cannot always be unequivocally attributed to failure of irrigation supply, and so the process of compensation becomes much more complex. This issue was the subject of protracted negotiations at Mahakandarawa in maha 1980-81.

The main obstacles to the adoption of early land preparation and sowing are more or less implicit in this list of the advantages of conventional practice. It is however useful to specify these disadvantages in detail. Although they interact with one another, they are more conveniently treated as five separate points:-

a) From the point of view of the individual farmer the adoption of kekulan involves a greater risk of loss of crop through weed competition.[1] It is not clear how far this risk can be reduced through improved skill and techniques on the part of the farmers. For example, it is argued that, with good and careful land preparation, weeds may be dealt with effectively even under semi-dry conditions. This will however depend in part on there being rainless spells during which the weeds dry out and can be removed or burned. Again, it is possible that the effectiveness of weedicides - which will normally be necessary with kekulan - may be greatly improved by the use of correct dosages and better spraying methods.[2]

b) Information collected by the TIMP staff and apparently corroborated by our own brief field enquiries suggests that an important reason why farmers do not adopt kekulan is lack of confidence that other farmers will do the same. For the advantage of the strategy can only be reaped if all farmers follow suit: otherwise it will not be possible to save water during maha by making only short and sparing rotational issues. The problem then becomes the lack of means to persuade or coerce all farmers into taking simultaneous action.

c) Kekulan is not equally attractive to all farmers. Quite predictably, the poorer cultivators are more averse than others to incurring the additional risk involved, insofar as they have a choice between kekulan and a reliably irrigated crop. As we have discussed, those without reliable irrigation supplies have no alternative but to adopt early (rainfed) planting. The fact that kekulan with 4wt generally requires less labour (in land preparation) than 'mudding' with buffaloes, is of more consequence to those who require to hire labour rather than to those who have adequate supplies of family labour. Those who for various reasons have never levelled their fields fully or who have fields supplied by drainage water from others face the prospect of receiving inadequate irrigation water during maha when only slight issues are made to meet the inadequacies of rainfall. None of these inter-farmer differences would be very significant if it were not for point b) above: the need for simultaneous adoption of kekulan by all (or most) farmers.

d) The success of early sowing depends on the availability and use of both the physical and the institutional means to control water, issue it sparingly and evenly, and to prevent large scale 'illegal' impounding of water by those intent on 'mudding'. Some success in water management was undoubtedly achieved by the TIMP on the Mahakandarawa scheme in the maha 1980-81 season, but in the context of a recent physical rehabilitation programme and a large administrarive effort fired by a great deal of special interest and support from above and a very unusual degree of co-operation between separate government departments.[3] Such special efforts may be

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[1] Note that the risk is all the greater because, due to lower seed germination rates and losses to birds and other pests, seed requirements for dry sowing are greater than for 'mudding'.

[2] Our own field investigation showed that farmers tended to blame the ineffectiveness of weedicides on the lack of adequate moisture in the few days after application. This view is apparently held by many agricultural officers, but it is not clear how valid it is.

[3] Rotational schedules and other agricultural matters were overseen on a tract basis by joint teams formed from officials of the Agrarian Services, Agriculture, Irrigation and Land Commissioner's Departments. Associated practices were detailed rotation schedules worked out for each plot and posted on signboards fixed at the heads of distributory channels.

almost essential if progress is to be achieved. But, just as much as they demonstrate what is possible, they reveal why it is not achieved in normal conditions. Even if the necessary institutional effort and co-operation could be reproduced on a wider scale, one encounters the problem of the dearth of physical means to control water. At the opposite end of the scale to newly-rehabilitated Mahakandarawa are schemes like Gal Oya, where physical means to control water are very scarce, and where water physically cannot even be delivered to some tail end tracts.[1] In between are a whole range of schemes, where the physical potential to control the volume and/or timing of water deliveries is very variable, even <u>within</u> the individual scheme.

e) Compared to 'mudding', <u>kekulan</u> requires both more support from government agencies in the form of credit, crop insurance, and early supplies of fertiliser and weedicides and, in the case of credit in particular, certainty about whether or not this will be available, in what quantities and at what times. Present rhythms for the supply of these agricultural inputs tend to be attuned to the normal timing pattern for mud cultivation. To ensure that they arrive on time for early land preparation and sowing has required a special effort. This special effort is possible only in the context of a special project which has a special over-arching management structure to coordinate the activities of the separate government agencies - the Agriculture, Agrarian Services, Irrigation and Land Commissioner's Departments, the banks and the Agricultural Insurance Board. In the absence of such special management, there is no institutional provision at scheme level to plan and coordinate the supply of inputs and to put pressure on the separate departments to ensure that they perform better than they would otherwise. The implication of these points was seen early in the life of the TIMP: it requires a special integrated, authoritative management structure on each scheme, not unlike that now adopted for the newly-developed Mahaweli areas.[2]

The supply of agricultural credit constitutes a special sub-category within this general problem area. Its peculiarity arises from the combination of three factors: (1) the enormous uncertainty about whether and in what quantities credit will in principle be offered to the locality and to the individual (in part the result of continually changing policies with regard to past defaults), (2) the great complexity of the procedures for obtaining credit, and thus the risk that even the nominally-eligible individual will for some reason fail; and (3) the fact that, because of low interest rates and low repayment rates agricultural credit is, once obtained, very valuable.

At our study locations, the reliance on official credit was very low, though informal credit channels involving interest charges of up to 10% per month, were an important source of funds, particularly to cover 'distress' requirements (Chapter 5.2). In view of previous defaults on

[1] Information on the paucity of physical controls over water flows in the Gal Oya scheme may be found in the contribution by H. Murray-Rust to the first Yearbook of the ARTI Water Management Project to be published by the Agrarian Research and Training Institute, Colombo.

[2] See R. N. Parker "Management of Major Irrigation Schemes in the Dry Zone", TIMP mimeo, 1978.

repayment, most farmers are forced to manage without official credit in the typical season. It is however clear, and was especially evident at Mahakandarawa in the 1981-82 maha season, that the prospect that they might gain access to this almost free good causes some farmers to delay land preparation rather than to obtain the resources from elsewhere - i.e. friends, relatives or private moneylenders - and get on with the job.

In sum, the main obstacle to the widespread adoption of early land preparation and sowing lie in lack of confidence on the part of the individual farmer that he will not lose his crop to weeds, that other farmers will also follow the same strategy, and that irrigation water and other inputs will be available in the necessary quantities at the correct time. To overcome this lack of confidence requires a management and planning effort which is greater and more integrated between separate agencies than that currently practised.

The Costs and Benefits of Early Land Preparation and Sowing. As has been detailed above, early land preparation and sowing appear to offer, in comparison to conventional 'mudding' techniques, the prospect of increases in area cropped, total agricultural production, and agricultural production per unit of scarce irrigation water. Without being able to assign quantities to the economic variables concerned, it is convincingly argues that the potential benefit:cost ratio to the national economy is high, even allowing for the increased dependence on tractor cultivation. The practice of early sowing is also promoted in the belief that it is in the economic interests of the average farmer. However, since farmers incur the additional risk of suffering reduced yields without any compensating reduction in water use cost, the subjectively perceived benefit:cost ratio to them will be somewhat less than to the national economy, and it seem only in areas (such as the trial location, Mahakandarawa) where irrigation water is frequently inadequate for a full maha crop under mudland tillage that kekulan has a chance of adoption.

It may however be misleading to end the analysis by looking at the potential costs and benefits to the average farmer. For there are fairly wide socio-economic differences among cultivators on irrigation schemes (see Chapters 3, 4 and Appendix 8). To some degree these differences determine the attractiveness of early land preparation to the individual farmer and thus affect the practical feasibility of the early sowing strategy as a whole (see above). For example: poorer farmers are less able and willing to take the increased risks involved in early sowing; those who depend mainly on family rather than hired labour are less attracted by the fact that early sowing tends to save on labour in the maha season; those whose land is near the tail end of main or distributory channels may fear that, if there is any lapse in the irrigation rotation system, the light irrigation water issues made during the maha season would be less likely actually to reach their fields than the normal issue.

In addition to factors of this kind, there are other ways, not necessarily evident to the farmers themselves, in which the early land preparation and sowing strategy might threaten to increase economic inequalities between rural households: (a) early land preparation places a premium on ploughing by 4wt rather than by buffalo and thus, for reasons given above (see Chapter 5) helps accentuate the growth of inequality. The ownership of tractors leads to wealth and land accumulation more rapidly than does the ownership of buffaloes. Since their ownership is concentrated near the top ends of irrigation schemes, the opportunities for access to hire services may be weighted against tail enders; (b) early land preparation

and sowing are not compatible with the practice of transplanting paddy. Given the general slow island-wide trend towards the wider adoption of transplanting as the man-land ratio increases it becomes clear that, if it became widespread, kekulan would be land replacing in this operation. Whether it would reduce or increase the overall demand for labour - and thus the incomes of the rural poor - would depend on how much extra land could be cultivated each year as a result of water saving in maha. However, even if the aggregate labour demand were to be the same or greater than in mudding, there would still be a new loss of job opportunities to poorer rural women. For there is a high degree of gender specialism in paddy labour, land preparation is almost entirely men's work. Women are engaged mainly in transplanting, hand weeding and harvesting. Insofar as the very poorest rural households are those which depend mainly on the wage earnings of unskilled female labour,[1] then their living standards are threatened by agricultural techniques which reduce the demand for labour in transplanting and hand weeding.

6.4.4: Conclusion

There are doubts about the income distribution consequences - and thus the desirability - or early land preparation and sowing which may not have been foreseen by those engaged in promoting the practice. These are however secondary to the more difficult question of whether the strategy is at all feasible as a substitute for mudland preparation. The answer to this depends ultimately on evaluation of the possibility of changing the structures and procedures of local level administration in order to achieve the kind of integrated, activist, competent and planned managerial interventions necessary for the strategy to succeed (see above). The constraints are organisational, and are ultimately of much the same kind as those facing any attempt to make government intervention more effective in promoting development at the local level. There are contradictions which are neither new nor trivial, between the type of official action needed and the normal operating procedures of government agencies.

Perhaps the most confident general conclusion one can reach about the prospects for the spread of early land preparation is that it will at best be slow, and is likely to be limited to those schemes where:

a) water for a yala crop is regularly scarce, and seen to be scarce;[2]
b) the physical infrastructure for water management is well developed and maintained (which in most cases means after an effective rehabilitation programme); and
c) the practice of a mudland tillage followed by paddy transplanting is not already well establishes.

This may mean in effect that, at best, there is little prospect in the foreseeable future of early land preparation becoming the standard technique outside (some of) those five schemes currently covered by the Tank Irrigation Modernisation Project.

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[1] Moore, M. P. & Wickramasinghe, G. (1980).

[2] It may prove difficult to introduce early land preparation and sowing on schemes which can receive irrigation water from the Mahaweli programme. Without a radical change in the methods and environment for water management, farmers will generally prefer to agitate politically for Mahaweli water.

CHAPTER 7: CONCLUSIONS AND POLICY RECOMMENDATIONS

This study, conducted at a time of intensified official efforts to achieve the related objectives of population re-settlement and enhanced agricultural production in the Dry Zone, has attempted a re-assessment of the role of a key production input in smallholder farming - draught power - both in its own right and in its potential role as a partial substitute for the most constraining farm input in the Dry Zone, viz. irrigation water.

Much of the early official support of mechanisation saw tractors as a means of advancing and synchronising the cultivation calendar on the relatively large irrigated and rainfed paddy holdings under cultivation in the Dry Zone of the early 1950s. Not only would they thus permit more efficient use of water to be made, they would also compensate for shortages of hired labour at peak periods with anticipated beneficial effects on timing, yields and cultivated acreages. A variety of monetary, fiscal and administrative measures were therefore deployed to promote the ownership of tractors in private hands, the establishment of officially-administered tractor pools and the provision of subsidised tractor hire services. No corresponding initiatives were taken in the promotion of animal draught (Chapter 2).

As a consequence of these incentives, the import and use of tractors in small farming became widespread, some 45% of the national paddy acreage being ploughed by tractor by the late 1970s (Part 1 Report, p.160). With limited allocations of foreign exchange for tractor purchase in the late 1960s and early 1970s, with even more severe limitations on the import of a partial substitute in transport activities, viz. lorries, and with the difficulties of obtaining spare parts through state-monopoly distributors, the profits accruing to the use of those tractors in working order reached very high levels in the early 1970s (Chapter 6.2). By the time of import liberalisation in late 1977, therefore, there was considerable 'pent up' demand for the purchase of new tractors in anticipation of obtaining similar profits. In addition to the upsurge in private tractor purchase after 1977, numerous official schemes - frequently foreign assisted - were set in motion for the allocation of tractors to smallholders in major irrigation.

Three major shifts in the focus of official policies have occurred since 1950: first, the degree of direct state administration of tractor pools with the provision of subsidised hire services to smallholders has been reduced to zero; second, the subsidies provided (initially) in allocations of foreign exchange, import duties and, until recently, in fuel subsidies and depreciation allowances have been largely discontinued, the only major remaining incentive being in the provision of credit for the purchase of tractors to smallholders who would, under normal commercial criteria, be regarded as having insufficient collateral for the large sums involved. Finally, with the reduction in size of irrigated allotment granted under settlement projects since the early 1950s, the promotion of tractorisation in major irrigation faces more severe disparities between the potential scale of operation of 4wt and the mean allotment size of owners and hirers than when initial decisions in favour of tractorisation were taken.

In view of the large burden on the public purse imposed by strategies of subsidised foreign exchange availability, low import duties, ubsidised credit and so on, which have been adopted in order to promote tractorisation, the question of whether tractors have made a net contribution to national economic welfare over and above what could have been achieved through the continued unsubsidised use of indigenous draught power sources assumes paramount importance.[1] With the continued focus of agricultural development policy on major irrigation schemes, we have chosen these as the socio-economic setting in which to examine the impact of tractorisation.

7.1: Characteristics of Draught Power Ownership and Use

Whilst the size and composition of the farm power stock is the product of varying historical and environmental circumstances at the three study locations, the ownership of tractors is uniformly concentrated towards the top ends of irrigation command areas, so that those living at the tail ends are faced with more severe difficulty than top enders in securing tractor hire services (Chapters 2.5 and 6.2). The spatial distribution of buffalo is more even, but ownership concentrations, reflected in average herd sizes, differ widely among study locations, and are associated with differing husbandry and feeding practices, the large numbers of small herds at Kaudulla being kept and fed principally on the homestead, whilst large herds (at Uda Walawe and Padaviya) are allowed to graze in the scrub jungles surrounding irrigation schemes, being brought into the scheme chiefly during cultivation periods. There is thus wide scope for improved efficiency in buffalo husbandry through first, the promotion of more widespread stallfeeding, and second, the intensification of stallfeeding through production and feeding of crop residues having higher calorific and protein values than cut grass.

There is a strong tendency for the ownership of tractors (especially 4wt) to be associated with the operation of multiple economic enterprises, of which farming is not necessarily the most significant in terms of net income generation (Chapter 5.3). One consequence of this is the tendency for 4wt owned by 'businessmen' (as opposed to 'farmers') to spend much of their time in non-agricultural operations[2] (Part 1 Report, p. 60 ff). Such work does not, however, absorb substantial proportions of tractor time at peak agricultural periods, with the exception of those areas (e.g. Uda Walawe) in which the opportunities for non-agricultural work are particularly favourable (Part 1 Report, Figures 1-9).

In most cases, farms on which tractors and buffalo are owned and used in Sri Lankan irrigation schemes are small, rarely exceeding 6 acres of paddy and most commonly in the 2-5 acres range. The cultivation of non-irrigated crops is minimal in most areas (0-1 acre) except in those locations (e.g. Padaviya) where land is conveniently available for the

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[1] Particularly in view of the high costs of using tractors as opposed to buffalo for tillage (Appendix 9). To demonstrate that large (private) profits accrued to the operation of tractors would be insufficient, since without some net effect on, e.g. the efficiency of land, labour or water use in agriculture, such profits would represent merely a reallocation of resources within the economy.

[2] Whilst, in informal interviews, the majority of tractor owners had expressed a preference for the relatively clean and less mechanically arduous use of their tractors in haulage, it is clearly those with substantial non-farming enterprises who are in the stronger position to obtain such work.

large-scale cultivation of rainfed paddy. The farms of potential hirers are somewhat smaller, commonly 2-3 acres of irrigated land. Farm sizes as small as these are in themselves substantial obstacles to the intensive use of tractors. Where the tillage performance of 4wt is some 1.5-2.0 acres/day of full land preparation (and, therefore, 3.0-4.0 acres/day for a 'first' ploughing), it will be necessary to arrange more than one hire contract per day, possibly with substantial travelling time between contracts, if the tractor is to be fully utilised (Chapter 3.2-3.3).

A more substantial obstable lies in the small size of liyadde (i.e. bunded plot) within which tractors conventionally operate. These are commonly of 0.1 acre and impose severe penalties on the operating efficiency of 4wt through frequent turning and reversing (Chapter 3.3). There is no evidence to suggest that the paddy farms of those who conventionally use tractors for tillage have been adapted to 4wt operating requirements through the creation of larger liyaddes; these remain small for ease of water regulation.

7.2: Tractorisation and Agricultural Production

The assembled evidence suggests that the use of tractors in the mudland tillage systems practised almost universally in major irrigation has not contributed to an improvement in the timing or synchronisation of paddy cultivation (Chapter 3.4., Appendix 3.4). Even in years when rainfall in the early maha monsoon is adequate for mudland tillage, it is the start of irrigation water issues that mark the beginning of agricultural activity on paddy allotments. Where an Irrigation Engineer has the confidence of farmers and can prompt them into starting cultivation through (light) early issues of stored water, they will accept his commitment to compensate for any shortfall in rainwater in the critical crop establishment period. The availability - and efficient use - of irrigation structures to permit the precise allocation of water only to those areas with water deficits would no doubt permit further water saving and increase farmers' confidence in water administration (and their willingness to cultivate early). Much therefore depends on the creation of a climate of confidence between Irrigation Engineers and farmers, and on the sensitive administration of water as a means to the end of agricultural production. Set against these factors, the influence of 4wt on the timing of cultivation in major irrigation is negligible.

Paddy seasons are marked by the start and finish of water issues. The maha harvest will generally be complete before yala issues begin. In these circumstances, a higher annual cropping intensity (i.e. a higher percentage of the available land cultivated during yala) will stem only from improved timing and synchronisation of the maha crop. We have argued that tractors make no contribution to such improvements in timing, and data on cropping intensities confirm that those achieved by tractor owners are no different from those of non-owners (Chapter 3.4).

Irrigated paddy yields are some 5 bu/ac higher on average among tractor owners than among non-owners. The evidence from agronomic experiments (c.f. Farrington and Abeysekera, 1979), however, indicates that the quality of tilth and control of weeds achieved under tractorised ploughing shows no advantage over traditional systems. Nor can yield differences arise from improved timing of cultivation. Significant differences do, however, exist in the application of other yield-influencing inputs between

owners and non-owners: the farms of owners are generally better-located in respect of irrigation water supply, their use-levels of fertiliser are higher, as are their adoption levels of transplanting (Chapter 3.4).

As far as current systems of production are concerned, tractors show clear advantage over traditional draught systems only in the cultivation of large expanses of rainfed land. Traditionally, 'slash and burn' techniques, involving the use of fire as a major tool in land preparation, have permitted farm families to earn (barely) adequate livelihoods from rainfed cultivation without the use of large volumes of hired labour. In areas where adequate land remains for the long fallow cycles incorporated in this method, tractorisation can achieve a more rapid opening up of land, and providing that adequate control of weeds is obtained through cultural or chemical methods, a higher sustained cropping intensity over a period of years than can be achieved by shifting cultivation. Where shortages of land have forced the fallow cycle into a short cycle of land rotation within settled farms, the use of fire becomes less effective and methods relying on manual labour provide adequate weed control only with very high labour inputs. The use of tractors in this context of settled rainfed farming is likely to permit a higher proportion of the farm to be cropped on a permanent basis, and may, as our data indicate, permit higher annual use-intensities of rainfed land (Chapter 3.4). However, the use of tractors in areas such as these has hitherto been minimal.

7.3: Tractorisation and Labour

The impact of tractorisation on labour use may be divided into three components: first, its impact on labour directly employed in agriculture; second, labour use levels associated with driving and maintaining the power source, and third, employment attributable indirectly to the power source in economic enterprises other than farming, transport or the maintenance of the power source (Chapter 4).

In buffalo husbandry and use systems involving the individual ownership of small herds of animals, their tethering and feeding at the homestead and their use with ploughs, labour use in herd maintenance is high, comprising primarily family labour. If tractors replace systems such as these, the most significant form of labour displacement is from these herd maintenance activities (some 600 days p.a. per 4wt) followed by displacement from agricultural activities. Where buffalo maintenance and use practices are extensive, the total displacement (at some 500 days p.a. per 4wt) is less severe than under intensive systems (some 1,000 days p.a. per 4wt) and agriculture constitutes the main source of lost work opportunity. The labour displacement effects of 2wt use are substantially (approximately 50%) less severe.

With both the expansion of tractor use through more intensive hiring out from the existing stock, and with more widespread ownership, involving an increase in the stock, the labour displacement from agriculture involves primarily family labour - some two thirds of labour displacement in the former case, and 85% in the latter. Overall labour use per acre on tractor owners' farms is substantially lower than on those of buffalo owners, so that the impact of more widespread tractor ownership would be a higher overall loss in employment opportunities than would be involved purely in an expansion of hiring activities from the existing stock.

Whilst tractor owners employ more labour in non-farming activities than do buffalo owners, the amounts of labour are small relative to their displacement effects in agriculture and in maintenance of the draught power source (65 and 19 days p.a. for 4wt and 2wt respectively), and it also appears unlikely that the bulk of this should be regarded as a net contribution to employment attributable to the use or ownership of tractors.

The major impact of displacement on family, and not hired, labour is contrary to the findings of tractor studies in other parts of the region. Whilst it is associated with heavier involvement of family labour in non-farm economic activities among the owners of tractors, this does not appear to be the case with those who hire in tractors, and much of this apparently voluntary withdrawal of labour is not directed into alternative productive activities. Both in its larger overall magnitude, and in the apparent unlikelihood of alternative productive activity, this form of labour displacement appears to be more severe than the displacement of hired labour in Sri Lanka's Dry Zone. Whilst the income distribution implications of displacing the poorer wage labour sector of the community are potentially more severe, the volume of work lost is smaller, and the continuing buoyant demand for labour in manual operations connected with land clearing, bund construction, levelling, planting, harvesting, threshing and winnowing (Figures 4.1.1-4.1.3) ensures that adequate opportunity for the re-deployment of at least some of the displaced hired labour (at the same times of season as its displacement) continues to exist.

It is worth emphasising that the observed pattern of labour displacement is very different from that initially perceived by policy makers, who intended that tractors should substitute for scarce hired labour. In the event, in spite of tractorisation there remain strong potential bottlenecks in peak labour demands at land preparation/planting and harvesting/threshing - more than half of which is for hired labour in these operations. On the other hand, evidence from the Polonnoruwa paddy areas (of which Kaudulla forms part), which are only moderately distant from the Wet Zone, and which offer abundant scope for casual employment, indicates substantial flows of seasonally migrant labour from the Wet Zone. This valuable resource makes a high additional contribution to output and has positive income-distribution effects at low opportunity cost, yet it has been widely neglected in official circles. There remains a need to assess the extent to which migrant labour is necessary and could be officially promoted (through subsidised recruiting, transport and accommodation) in areas more remote from its Wet Zone origins (such as Padaviya) where its role is currently minor. Indeed, it would scarcely be an exaggeration to suggest that the official promotion of seasonal migration in the development of colonisation schemes would have provided a viable, and potentially much more socially profitable, partial alternative to tractorisation.

7.4: Tractorisation and the Distribution of Income and Wealth

By tradition, the access opportunities to draught power in Sri Lanka have been wide, and have commonly been governed by non-market considerations. Thus, the reciprocal pooling of small herds to make up a viable buffalo team for 'mudding' or threshing, or the borrowing of animals from larger herds, was common. Where payment was required for hiring, it normally took the form of a crop share (subject to reduction in the event of poor harvest) or of the provision of labour services. The emergence of cash payments for hired labour in the early twentieth century was

followed by some monetisation of draught animal transactions, though this seems to have gained ground principally with the establishment of colonisation schemes in which the levels of social cohesion and mutual trust necessary for traditional shared-access arrangements were lacking. The carryover of these traditional arrangements is not impossible, however: for 83% of the occasions when the small stall-fed herds at Kaudulla were used off their owners' farms, no direct payment in cash or kind was required.

With the rising recurrent costs of fuel, drivers, and maintenance for tractors, two forces are set in motion: first, tractor owners take the lead in setting increased hire charges, which buffalo owners then follow, so that the terms of trade are shifted against the (poorer) non-owners; second, the emphasis on cash payments has increased markedly: whilst the majority of buffalo hire payments were deferred to the end of season across the samples, and were made predominantly in kind, the same was true of less than 20% of 4wt payments. Tractors thus impose considerable extra burdens on the small farmer at a time when his cash reserves are likely to be particularly low, within the context of inadequate official seasonal credit schemes. They are thus a recipe for increased indebtedness and inequality at two distinct levels: first, in the additional burdens they impose on farmers; second in the extra opportunities they provide for capital accumulation, investment in small businesses (retailing, grinding mills) and related participation in the informal credit market with its high interest rates. The processes at work in the second of these mechanisms are as follows: funds for the purchase of a tractor are commonly raised through the high returns to farming obtained by those with plots favourably located in respect of irrigation water. Part of the economic rent obtained in this way may already have been invested in the control of other paddy land. Such investment mechanisms are normally indirect, involving the advancing of loans in the informal credit market, with land as collateral. The (not infrequent) default on repayment involves transfer of cultivation rights to the lender. Investment may also have taken place in other small businesses prior to the purchase of a tractor.

A second major source of funds for tractor purchase lies in the financial gains made by some of those holding position in which embezzlement, fraud and bribery are possible. These include the staff of co-operatives and marketing organisations, and public sector employees responsible for contractual arrangements with the private sector. Widespread reports were received in the course of fieldwork of ownership of 4wt by persons in these positions whose salaries would not have been adequate to permit such purchases.

A third - relatively minor - source of funds is to be found in the profits of those with long-standing business interests at the locations surveyed, the agricultural component of their enterprises having been significant only in the distant past.

It is significant for distributional considerations that a major role in the accumulation of funds for tractor purchase in two of the three cases above is played by income derived from either economic rent or from corrupt practices. Tractors are a source of increased inequity to the extent that first, they may have increased the scope for investment of such funds in the rural community and, second, the rates of return they offer may be particularly high, and thus to widen the gap in economic status between those having and those not having access to such sources of funds.

The rates of private return on investment in tractors have been and remain substantial. In the early 1970s, a 4wt earned sufficient revenue to repay its purchase costs in approximately 2 years, and a 2wt in 18 months. At present, following a major influx of tractor imports since 1977 and the more ready availability of spares for the existing fleet, the annual rates of return are approximately 25% of current value on a 4wt and 20% on a 2wt.[1] It is likely that respondents have not reported some of the gains attributable to tractors, so that these rates of return may represent underestimates.

The potentially divisive distributional impact of tractors is not limited to these directly attributable rates of return, however. The profits they generate directly reinforce their owners' capacity for investment in whatever worthwhile opportunity might emerge: perhaps a paddy store and grinding mill, a commercial vehicel or a retail store. All of these offer further potential for exploitation of poorer sectors of the community through, respectively, malpractices in weighing paddy, high transport charges and usury. Some redistribution of land in favour of tractor owners has also taken place. At one location (Padaviya) 4wt owners' paddy land had more than doubled since arrival at the location, whereas that of non-owners had remained constant, at one quarter of the current 4wt holding. Accumulations at other locations were much smaller. The sensitive nature of this issue again makes it likely that the data presented are underestimates.

Current estimates indicate that the net income of 4wt owners are higher than those of non-owners by a factor of 16, though, for the reasons stated above, this may underestimate the gap. The extent to which the social and economic relations arising from these disparities have led to an increase in the exploitation of one sector of the community by the other is difficult to quantify. On balance, though, tractors have undoubtedly constituted a major force in the widening of this gap - over 30% of tractor owners' income, for instance, is directly attributable to tractor operations - and it seems most unlikely that the concentration of economic power to which they have contributed will have been used in an entirely neutral fashion.

7.5: The Social Costs and Benefits of Mechanisation

A fundamental condition of sustained investment, and therefore of achieving production levels adequate to meet the community's needs in capitalist economies is that adequate rates of return must accrue to private investment in productive resources. Calculations from this and from previous studies indicate that the rate of private return has been extremely high, and remains moderately good. The surge of private imports following the 1977 General Election bears witness to this.

The extensive subsidies on tractors, and the fact that much of the private gain derives from re-distributive rather than from net productive effects, imply that social benefits are likely to be substantially lower

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[1] Excluding the Padaviya sample, where the combination of a poor agricultural year, heavy repair costs and high tractor numbers in relation to the volume of work available, has drastically reduced profitability for the survey year.

than private profits. Preliminary calculations suggest that the strategy of tractorisation in the period 1953-79 has generated higher social costs than benefits: a deficit of some Rs.2,400m. over the period has been incurred, implying that only 70% of the costs of importing tractors has been recovered through productive gains.[2] An increase of 50% in these gains, without any cost increase, would be necessary to bring the benefit: cost ratio to 1.00. In spite of the uncertainty surrounding the calculations, it seems unlikely that benefits could have been underestimated to this extent. This analysis - for the national tractor fleet, not merely those used in the Dry Zone - suggests that two-thirds of the benefits realised originate in non-agricultural work, a result far removed from the anticipated benefits in agricultural applications expressed in early mechanisation policy.

If this generation of social disbenefits is to be reduced for those tractors currently in use, steps will have to be taken:-

i) to restrict severely the future volume of tractor imports,
ii) to increase the use intensity of the existing tractor stock from the low observed levels,
iii) to ensure that such increased use intensity represents a net contribution to production by tractors, and not merely the substitution of (expensive) tractor draught in operations which (cheaper) animal draught can perform adequately,
iv) to promote a more balanced rural infrastructure, so that transport work in construction, crop extraction and storage, and other rural industries is available for those tractors currently based in agriculture during the off-season,
v) to ensure adequate maintenance and spare parts facilities so that loss of tractor time through breakdown is avoided.

To achieve higher use intensities, and to increase the proportion of such use which generates net productive (as opposed to re-distributive) effects is the most complex of these requirements, and, at the same time, is likely to offer greater potential gains than any other. Consideration of it is reserved for the following section.

7.6: The Prospects for Increasing Farm Power Efficiency

The current low use levels of farm power directly result from the fact that farm power stocks have increased rapidly since the 1977 trade liberalisation, reaching a point where new tractors are difficult to dispose of in the agriculture sector. The indications are therefore that the tractor market is saturated and that, for this reason and those mentioned above, imports should be restricted.

Further factors, however, contribute to low overall use levels and a pattern of tractor use which largely substitutes for traditional (and socially less expensive) animal draught instead of making a strong net contribution to productivity. These can be grouped broadly into (i) imperfection in the power hire market, and (ii) inefficiencies in the irrigation infrastructure.

(i) The power hire market

The growth in tractor populations relative to asweddumised acreage since 1977 has not led to the fierce competition and lowering of hire rates which could be expected to occur in a smoothly functioning market. Indeed, all the indications are that such markets function inefficiently. There are several reasons for this, some structural, others behavioural:
- Tractors are concentrated into few hands and their spatial distribution is heavily skewed towards the top ends of irrigation schemes, making access to them difficult for the bulk of would-be hirers;
- There is neither a physical market for, nor a comprehensive information network on, tractor hire - lines of communication rely on word of mouth and the personal visiting of tractor owners by potential hirers. Because of the time and expense this involves, there is a tendency for established patterns of hire to be repeated from year to year;
- In practically all cases, tractor owners made no effort to 'sell' their services in spite of some dissatisfaction with the volume of work available;
- The majority of owners and non-owners perceived hire charges as fixed, and some owners spontaneously volunteered the information that charges were set as a result of collusion among owners.

Nor did any increased competition arise from the buffalo owning community. On the contrary, these tended to follow the hire charge lead of tractor owners in raising their own rates, and appear to have reaped some economic rent as a result, thus shifting the overall terms of trade against those who owned neither power type - i.e. the broad majority of farmers.

Two conclusions arise: first, speeding up and synchronising operations, particularly at land preparation, by assisting owners to keep their tractors fully occupied during this period may lead to a less randomly-staggered cultivation season, with the benefit of increased water storage for the following season. In turn this implies an increased acreage, more work for draught power, and an increase in returns to factor inputs (including tractors) for the year as a whole.

Second, high charges by both tractor and buffalo owners have shifted the balance for the majority of farmers (i.e. non-owners) in favour of attempting to purchase a power source instead of hiring it in. Clearly, buffalo represent the most feasible option, and, in social cost-benefit terms, by far the least expensive. Whilst there may remain some role for a much-reduced tractor stock, emphasis in many areas for the future should be placed on broadening the base of buffalo ownership on the Kaudulla model of stall feeding with minimal grazing. This strategy is likely to be implementable in the medium term only, so that it does not necessarily conflict with the requirement of using a static or declining tractor stock more intensively and productively in the short term.

(ii) The irrigation infrastructure

The scope for increased efficiency in the consumption of stored water in major irrigation depends on the capacity of tractors for increasing the returns per unit of water† indirectly through net contributions to yields, cropping intensities or the value of output which could not be achieved by animal draught, or on such direct effects as an advancement of the agricultural calendar to permit greater use of early season rains, and a reduction in the degree of (disorganised) staggering of cultivation among farmers.

† And, insofar as this can be achieved by tractors but not by other power types, the returns per unit of tractor time.

The thrust of our argument is that indirect benefits of this type have not emerged, and are unlikely to for the future. Similarly, as far as direct effects are concerned, the available evidence suggests that it is decisions concerning the timing of water issue which determine the starting point of the agricultural season under conventional mudland tillage, regardless of the availability of tractors. The motivation and efficiency of the irrigation bureaucracy has therefore a major influence on productivity. Whilst the degree of staggering may be related to the overall volume of farm power, it does not, under current and foreseeable systems of water management in major irrigation, depend on the size of the tractor stock alone.

Only in one set of early tilling strategies currently under investigation (the 'kekulan' or 'dry' sowing under the TIMP) does a high degree of reliance on tractor tillage appear necessary. The degree of organisational effort required for the success of these strategies, however, makes their early or widespread implementation improbable (Chapter 6.3).

Where a high proportion of irrigated land is commonly cropped in yala immediately preceding kekulan sowing in maha, it appears that ploughing by buffalo on moisture residual from the yala crop followed by a light (buffalo or tractor) second ploughing prior to sowing, offers an intuitively appealing alternative which merits widespread agronomic appraisal.

Major improvements can, however, be made to water use efficiency under current mudland tillage systems, which are independent of the type of draught power used. Some of these require modest infrastructural investment; all require (to varying degrees) improvements in organisational efficiency. We discuss these in more detail in our recommendations below.

7.7: Recommendations

As we have repeatedly emphasised, major irrigation in the Dry Zone has formed the focus of our study, and it is within this continuing initiative towards smallholder resettlement and enhanced agricultural production that the following recommendations are made.

1. Policy initiatives designed to promote tractorisation during its initial stages were, in respect of colonisation schemes, based on confused and sometimes contradictory reasoning. In particular, the precise methods by which tractors might substitute for such scarce inputs as labour and irrigation water were not clearly identified. In practice, two unanticipated results have occurred: tractors have permitted the widespread withdrawal of family labour with a continuing substantial demand for hire labour, and farmers' attitudes towards the earlier cultivation necessary to reduce water consumption have depended not on the availability of tractors, but overwhelmingly on their confidence in the availability of irrigation water to compensate for lack of rain. In addition to these two basic factors, the successive reductions in holding size in major irrigation over the last 30 years have made efficient tractor hire operations more difficult (the hire market being in any case highly imperfect), and the social cost of tillage by tractor now greatly exceeds that by animal power.
   In the period 1953-79, the costs of tractorisation (for 4wt) have exceeded benefits by some Rs.2,400m. Only 70% of costs have been

recovered. Only approximately 44% of 2wt costs have been recovered by benefits, but the total disbenefit, at some Rs.345m., is much smaller than that of 4wt.

There appears to be a continued role for tractors in certain high-productivity activities, such as expanding cultivation under rainfed conditions and transport in construction projects. This would, however, require a far smaller tractor population than currently exists. The emphasis should therefore be on restricting future tractor imports and running down part of the existing stock. The social profitability of operating the remaining fleet could be improved by the locating of rural industries requiring short-haul transport in areas where tractor densities are high (such as major irrigation schemes). There are also (limited) prospects for increasing the joint returns to farm power and water by more widespread kekulan sowing in maha, relying on tractor tillage, at certain colonisation schemes, which would permit larger acreages under a yala crop.

There is certainly no case in the foreseeable future for any re-introduction of the range of tractor-support measures adopted throughout the 1950s and 1960s. Officially-sponsored credit schemes for tractor purchase by small farmers should also be discontinued: small farmers find it difficult to obtain enough work to make tractors pay, even in terms of private profits, and there is very little prospect of their being socially profitable. Additionally, there is abundant evidence that such schemes are abused by non-target groups such as businessmen and civil servants.

2. Trends in draught hire charges since the fuel crisis in 1973 have shifted the terms of trade against the great majority of farmers who rely on hiring in farm power, and there seems little prospect of directly removing the imperfections in the draught hire markets which have contributed to that shift. The ownership of draught power has therefore become attractive relative to hiring it in. A pair of buffalo - at only some 10% of the cost of a 2wt - appears a particularly attractive proposition. Reproduction rates are, however, slow, and there are large spatial imbalances between the requirement for and stocks of draught animals. Nor are there established markets for the purchase and sale of working animals. These factors require government intervention. The scope for official support is particularly pressing in newly settled areas (i.e. especially under the Mahaweli project) where existing stocks of draught animals are low. Buffalo are successfully kept under tethering and feeding systems in large irrigated areas of the Dry Zone (e.g. Polonnoruwa), bearing close similarity with the proposed Mahaweli systems, without the need to set aside cultivable land for the production of fodder crops.[1]

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[1] By contrast with other countries in the Region, Sri Lanka is fortunate in having relatively low population pressure on land resources in the Dry Zone, so that some grazing of animals is possible. Additionally, the year round provision of water in many major irrigation schemes makes verges and reservations an abundant source of fodder.

We therefore recommend that a policy of official support for the promotion of animal draught should be vigorously pursued, and should comprise:

i) as a short term measure, the relocation of working animals from areas of surplus to those of deficit (especially the Mahaweli areas), with appropriate provision of programmes for veterinary inspection, for training the animals, and for feeding juveniles to maturity.

ii) the establishment of medium term credit facilities with interest rates and collatoral requirements which contain concessionary elements, to permit the purchase of draught animals in all major irrigation schemes, but particularly in the newly settled areas.

iii) the official promotion of livestock markets for the sale of (officially bred or re-located, and privately offered) working animals.

iv) for the medium term, the establishment of breeding programmes to expand the draught animal population in areas of agricultural development are desirable. These should not, at least initially, aim to introduce high components of exotic stock. The objective should be to increase the supply of (albeit relatively small-framed) indigenous stock capable of working under the poor standards of feeding and management likely to exist in the initial stages of expansion of animal draught.

The pattern of official support for animal draught in the medium term should be determined largely by the levels of success achieved by individual components of the above programme.

A system of monitoring such a programme, and the capacity to develop a flexible response to varying levels of success are therefore essential.

The costs of such a programme are difficult to quantify. It is possible, for instance, that after initial official support, some aspects of the programme (such as rural cattle markets) may become self-sustaining. In all events, the direct costs are likely to be trivial by comparison with the costs which can be saved by reduced reliance on tractors. Unquantifiable benefits, such as a reduction in the degree of inequality of incomes and wealth in the rural community are likely to be large. At the same time, there is unlikely to be any loss in either local business initiative or in agricultural production through increased reliance on animal draught for the bulk of farmers. This is borne out by observations at Kaudulla, where a high reliance on animal draught already exists.

Several possible features of a longer term programme for the development of animal draught can be identified:

(i) the attempt could be made to increase the weight and stamina of indigenous stock by the promotion of feeding systems which will provide higher calorie and protein intakes than the present method of cutting and feeding grass from verges and reservations. They may incorporate the processing of crop residues - paddy straw is one possibility currently under investigation[1] - and, in areas where the yala cultivation of non-paddy crops expands, the feeding of waste and by products from leguminous and cereal crops. Further, informal enquiries during the course of our survey revealed that the rice bran produced in large quantities in the milling complexes of Polonnoruwa is frequently disposed of as a waste product. Clearly this could also be incorporated into more intensive feeding systems.

[1] At the National Livestock Development Board/Netherlands Government Dairy Development Project, Victoria Farm, Teldeniya.

(ii) with attempts to promote yala cultivation of non-paddy crops, and with the possibilities of ploughing on residual moisture as one component in a programme to reduce irrigation water consumption, the desirability of owning water buffalo - pre-eminently suited to mudland cultivation - declines vis-a-vis that of owning bullocks. The additional prospect of using bullocks in haulage - in which the use of buffalo is not customary in Sri Lanka - makes the attempt to bias the promotion of animal draught towards the ownership of bullocks appear worthwhile for the medium term. There are, however, two potential obstacles: first, the tradition among Sinhala paddy farmers - no doubt linked with their preference for mudland tillage - is for the use of buffalo in field operations. Second, those minority ethnic groups who do use bullocks in field operations conventionally provide dietary supplements (of rice bran or sugar cane by-products) prior to periods of peak activity. The capacity to provide an improved diet must therefore be demonstrated prior to the introduction of exotic or exotic cross breeds. Strategies of promoting this dual purpose animal therefore need to proceed with some caution.

3. Policy decisions in transport and agriculture sectors have frequently been taken under the pressure of recurrent crises in the balance of payments. Such decisions have important repercussions on the draught power stock. The 1977 initiative to 'accelerate' the Mahaweli project, for instance, biased the draught power mix for the early stages of that project towards tractors for the simple reason that inadequate time was perceived to be available for the (perceived) necessary purchase and breeding of draught animals. The vastly increased pressure on the administration resulting from this 'acceleration' also makes it less likely that adequate resources will be devoted, sufficiently far in advance of human resettlement, to permit plans for the supply of draught animals to be drawn up and implemented.
By contrast with the several years required to achieve substantial expansion of the buffalo population, the possibility of importing tractors within a matter of months provides an attractive - and, in many cases, through inadequate advance planning - the only alternative.[1] We therefore recommend that a government agency be charged with the responsibility of making initial draught power surveys at the earliest stages in planning agricultural settlement projects, and ensuring that due recognition is given in the phasing of project implementation to the long 'lead time' required for expansion of buffalo herds.

4. Wide discrepancies exist between those located at the upper and lower ends of major irrigation schemes in levels of income and wealth. The ownership of tractors is heavily biased towards the top ends, so that access opportunities to this, and to many other resources, are less favourable at the tail ends. Strategies development to expand the role of animal draught should therefore attempt to redress in some measure the current imbalance in resource access opportunities. One simple step in this direction could be taken by locating official efforts to promote animal draught (cattle markets, extension and credit services, veterinary facilities etc.) in the lower reaches of command areas.

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[1] Conceivably, the benefits to tractorisation could be high if it permitted the stream of incomes from irrigation development to be brought forward. Hitherto in Sri Lanka, however, draught power planning in such 'accelerated' programmes has followed the decision to accelerate only after a considerable interval, and has been inadequate through its failure to acknowledge the possibility of relocating part of the under-utilised stocks of buffalo from some remote parts (e.g. Padaviya) into development areas.

5. We have demonstrated that the use of tractors is generally neither necessary nor sufficient condition for improvements in water use efficiency in major irrigation. Much of the existing loss of stored water is attributable to low levels of co-operation and understanding between farmers and the irrigation bureaucracy. These, in turn, are caused by high rates of turnover of senior irrigation staff within schemes; the lack of familiarity among senior staff with the detailed actual (as opposed to designed) functioning of their system, inadequate reporting of highly localised rainfall, the lack of precise means of reducing the water supply to those areas which have received rain and the lack of incentive among irrigation staff to use water efficiently as a means to the end of agricultural production. Low morale among irrigation staff generally, and the inadequate application of some agriculture-oriented measure of irrigation efficiency, such as the water issue per acre of cropped paddy (or, perhaps better, the paddy yield per acre-foot of water issued), as a criterion for career advancement in irrigation staff, also take their toll. Many of these problems are symptomatic of a widespread and enduring malaise in the administration. Improvements require much detailed effort and are likely to be achieved only slowly. They are nonetheless essential to major improvements in water use efficiency. For the short to medium term, certain measures likely to produce more immediate - if somewhat limited - results could be pursued. These include:
   (1) the investment in necessary physical structures - particularly cross regulators on main and distributary channels - necessary to remit greater accuracy in the timing and placement of irrigation water; training of irrigation staff in the use of these;
   (2) the investment in communications networks which facilitate the reporting of local deficits or surpluses of water within a command area, this information forming the basis for adjustment to local water supplies, once the necessary control structures exist;
   (3) the collaboration of irrigation and agriculture officials in the promotion of an 'organised staggering' of cultivation in which irrigation water is supplied to the area served by one main channel some 1 or 2 weeks prior to the other. This would permit farm power stocks to be concentrated on one part of the command area, completing the bulk of land preparation there before transferring to the other. If the continuous flow of irrigation water generally issued for land preparation could be reduced by only one week as a result of concentrating land preparation into a shorter period, enough water would be saved to permit a 6-7% acreage expansion in maha in typical major irrigation schemes.

   This system depends on the availabilty of low opportunity-cost tractor time before and after the current peak agricultural activity periods, so that the 'peak' can be spread out in time. We have demonstrated that such slack does, in fact, exist.

The above measures could achieve substantial economies even within the existing context of mudland tillage. This should be the immediate priority in most major irrigation schemes. Once sufficient skill has been achieved in the 'fine tuning' of the irrigation system, and farmer-administrator confidence has improved, it may be possible to venture into systems which rely on rainfed tillage and sowing, irrigation water being issued only to supplement inadequate rainfall. For a small number of major schemes, the prospects of storing adequate water even for a maha crop may be uncertain, so that the search for rainfed tillage systems is more pressing. Here it may be necessary to rely on 4wt ploughing of the

hard soil on the first maha showers. Where a yala crop is possible, however, ploughing by animal draught on residual moisture represents an attractive - but much under-researched - possibility.

Priorities for research in the development of these rainfed tillage techniques include:-

- the assessment of alternative ploughing regimes which do not rely on 4wt, but instead utilise animal draught, possibly with ploughing on residual moisture as a basic feature.

- the development of short season paddy varieties which develop early leaf canopy and therefore assist in inhibiting weed growth.

- the assessment for dry sown paddy of the mulching, growth regulator, herbicide and planting techniques under development for upland crops under the zero and minimal tillage programme.

- more widespread experimentation with, and promotion of, non-paddy crops in schemes where water supplies are commonly insufficient for a maha paddy crop.

Finally, throughout the rapid and indiscriminate tractorisation of small farming in Sri Lanka emerge patterns of political and administrative behaviour - no doubt reinforced by the ready access to foreign capital offered by aid donors - which incline towards the prospect, no matter how inadequately identified, of a quick and easy solution to enduring problems. The unfortunate lesson of tractorisation in the Dry Zone is that large-scale foreign technologies have a severely limited role to play. In the search for higher levels of smallholder resource use efficiency they by no means serve as an adequate substitute for political and administrative will.

APPENDIX 1: FIELD SURVEY METHODOLOGY

1. Objectives

Existing information on the use-pattern of farm power in land preparation is fragmentary. No firm information exists on even such straightforward and critical variables as the average daily use hours per tractor or per animal pair, or the aggregate use-hours or acreage tilled per power source in land preparation per season. Little forward planning of land preparation technologies (i.e. including decisions on water use) is possible until more is known about the technical and market efficiencies of existing power sources, and what measures can most appropriately be taken to remove existing inefficiencies, or to avoid them altogether in planning new technologies or systems of organisation.

It was therefore felt necessary to embark on an extensive programme of field data collection, which would attempt, at a set of locations considered representative of Dry Zone major irrigation, to:

i) collect information from farm power owners on current types of power and implements used; their use levels and reasons for any restricted use; the land preparation technologies practised;
ii) collect from samples of farmers data on farming technologies, cropping patterns, labour and water use pattern, and hire charges for the main farm inputs;
iii) collect data from both owners and farmers on the organisation and efficiency of the power hire market.

2. Selection of Study Locations

The field data collection programme for this study was designed to provide data for a wide range of key variables in farm power and water use. The analysis of this data would then permit predictions to be made of the economic impact of changes in the combinations of such variables, and their quantities within the observed range. Additional data points could be obtained by supplementing both the number of variables and their observed range of values from experimental results and from reports relating to such variables under similar conditions in other countries.

For these reasons, the study locations were selected to give, when taken together, an adequate representation of a predetermined set of variables, namely:

i) both maha and yala paddy production should be represented, as well as irrigated and rainfed production of a range of other crops.

They should also:

ii) be well represented in the various categories of power input and in both owned and hired power;
iii) contain structures for the accurate measurement of irrigation flows;
iv) display a variety of institutional arrangements for the control of irrigation water supplies;
v) display a variety of holding and plot sizes, within which should fall those planned for wider Dry Zone development (especially the Mahaweli Project);

vi) display differences in water availability both within and across sites, so that an assessment of the variation in farm power use under different water supply conditions and of the potential net benefits of using water in alternative ways can be made.

Three further criteria were imposed in making a final selection of study locations from the fourteen potential sites identified on the basis of these initial conditions:

First, pre-survey observations indicated that a substantial portion of tractor time was spent in non-agricultural work. The availability of such work was observed to increase more than proportionally with increases in irrigation scheme size. For this reason, and in view of the need to select schemes large enough to contain adequate numbers of tractors to permit a sample to be drawn, it was decided to select study locations only from those 14 major schemes having more than 7,500 acres of paddy land.

Second, it was thought advisable to select at least one of those tanks which are linked by canal or drainage systems. This pattern of linkage will become much more widespread as the Mahaweli Programme is implemented. At the same time, farmers' attitudes towards water economy and towards practices and technologies which promote such economy may differ widely between tanks which have a self-contained catchment (and thus the benefit of any water saving would accrue directly to the farmers working under that tank) and tanks which are canal-linked (which to the farmer, may seem as though they have a guaranteed, and virtually unlimited supply of water, and any water saving would simply be passed on downstream to the next tank).

Third, given the development of the Mahaweli Ganga as a major national priority, it was thought necessary to pay particular attention to areas already receiving water through the Mahaweli diversion, and to areas envisaged as 'testing grounds' for some of the strategies to be implemented in Mahaweli - irrigated areas. In this connection, the Five Tanks under the Tank Irrigation Modernisation Project, based at Anuradhapura, were strong contenders for study. These two criteria, in addition to i)-vi) listed above, were relied upon in making the final selection of study locations. As submitted in the study proposal, it seemed likely that no more than three major irrigation schemes would need to be selected as survey sites to meet the stated objectives, supplemented by data currently being collected by other studies in other areas of major irrigation. The three selected schemes were Uda Walawe in the south, Kaudulla in the (east-central) Polonnaruwa paddy complex and Padaviya in the north-east. A more detailed description of the selection methodologies, and of the three selected locations is contained in Chapter 2.1 of the Part 1 Report.

3. Selection of Samples Within Locations

(A) Non-Owners. The most fundamental consideration in selecting non-owner samples within study locations was that variations in resource availabilities, particularly water availability and any consequent variation in farming patterns and practices, which were known to exist within selected locations, should be reflected in the sample chosen.

Repeated observations at the three selected locations in the first half of 1979 suggested that water availability in many circumstances varies both along the command area (i.e. from head works to tail end, along main channels), and across the asweddumised land (i.e. along distributory and field channels). These observations are confirmed

in a host of writings on the subject, but particularly by Chambers (1975).[1]

It was decided at each location to select samples from both upper and lower ends of the command area, and additionally, to take samples along at least one of the distributaries (i.e. across rather than along the command area). Variations in farming systems under different resource constraint patterns can thus be captured in both directions.

The sub-areas chosen for study, whilst conforming with this broad pattern, differ according to the individual characteristics of study locations. At some locations, for instance, a large number of farm holdings were situated within a selected sub-area. In such circumstances, it was thought advisable to select a part of the sub-area for farm level sampling. The underlying reasons for this are complex and revolve around the layout of irrigation infrastructure at distributory and field-channel level. This is determined largely by topography, and results in the construction of channels of varying lengths, with varying numbers of subsidiary channels. It is conceivable that a system of random farm sampling within an area as large as, say, a tract of 2,000 acres, with sample sizes limited by the resources available to the study, would result in over-representation of farms with adequate or more than adequate water supplies, and under-representation of those with inadequate supplies (or vice versa) given the complex of micro-level top and tail end positions within the channel network found at tract or sub-tract level. Nor would the water use activities of any of the sample farms necessarily influence the decisions of others in the sample.

The pattern of location and sample selection which emerged is as follows:-

UDA WALAWE

The Right Bank of the Scheme, comprising some 17,000 acres of paddy per season, was selected for study since much of the Left Bank system is still under construction. Tract 4 was selected as representative of cropping patterns and performances at the top end of the Right Bank. The longer of the two distributory channels within Tract 4 (D22) was selected since some water supply problems are experienced at its lower end. A sample of 40 paddy holdings was then selected at random from the 122 demarcated under this channel, with the intention of capturing both the systems and practices typical of the top end tracts, and any modifications to these imposed by intract (i.e. across scheme) water constraints.

At the lower end of the Right Bank, field observations suggested that cropping patterns and performance vary within short distances as the availability of water becomes critical. Variations are particularly marked between Tracts 18 and 19, double cropping of paddy being frequent in the former, but single cropping and the cultivation of subsidiary crops being more common in the latter. It was therefore decided to give representation to both in the samples. The last distributory within Tract 18 (D7) to be fed from the main canal was selected, as were the first and second (D1 and D2) in Tract 19. (The only remaining channel in Tract 19 to which irrigation water is

[1] Chambers, R. (1975) "Water Management and Paddy Production in the Dry Zone of Sri Lanka", Occasional Publication No. 8, ARTI, Colombo.

provided, D3, contains only 15 occupied allotments).

Allotment populations in these were:

D7 74 allotments - all occupied
D1 76 allotments - 28 occupied
D2 27 allotments - 24 occupied.

A sample of 20 allotments was drawn at random from the 74 in D7 (Tract 18) and a further 20 from the 52 occupied in D1 and D2 combined. These 40 farms constitute the 'tail end' observations for the Right Bank system. It should be emphasised that, in order to be reasonably certain of obtaining farm power use data from the tail ends, sample selection erred on the cautious side at all locations, insofar as only those allotments recorded officially as 'settled' were considered in the sampling frame. Some rainfed or very rarely irrigated cropping did take place in 'non-settled' plots, but on an irregular basis. To this extent data from our tail end samples tend to underestimate the severity of the tail end problem.

KAUDULLA

A brief description is given in the Part 1 Report (Appendix II) of development of Stages I and II under Lower Main Channel and Upper Main Channel respectively. It was thought that study resources were insufficient to permit the depth of coverage of both stages necessary, to yield statistically useable numbers of observations for the existing range of power and water use options. A choice therefore had to be made, and after much discussion with field staff of the Agriculture Department and repeated on site investigations, Stage I was selected. Factors such as the longer established irrigation (parts of Stage II having been developed only in the last five years, with consequent risk of a high proportion of transitional influences in any observations), the variation in holding size (Tracts 6-8 in Stage I are demarcated into 2 acre paddy allotments, whereas 1-5 have 3 acre allotments), the adequate representation in Stage I of water supply conditions observed in Stage II, and a more evenly balanced pattern of farm power ownership contributed towards this decision.

Within Stage I, Tracts 1 and 8 were selected for study, these being respectively at the upper and lowermost ends of the main channel. Tract 1 is by far the largest in Stage I (1,512 acres of a total 30P paddy acreage of 4,609 in Stage I) and is served by two long parallel channels, D1 and its subsidiary RBIB. It was within Tract 1, therefore, that the study of a farmer sample with water constraints along distributory and field channels was located. This tract comprises 504 individual lowland allotments, a number too large to permit adequate representation of areas of potential water constraints by direct random sampling. The following pre-selection of sub-locations was adopted: for the 'top end' study, 20 lowland allotments were selected at random from the 68 most immediately adjacent to the bifurcation of D1 and RBIB; to permit study of the tail end of Tract 1, the two longest field channels at the lower end of RBIB were chosen (FC15 and FC33), and 10 allotments each were randomly selected from the 24 and 27 holdings respectively irrigated by each of these channels. In Tract 8 a total of 20 allotments were randomly selected, 10 from a population of 24 at the top end of Tract 8 and 10 from 37 at the lower end.

It should be emphasised that buffalo ownership was extremely widespread in Kaudulla. In Stage I, for instance, 2 out of every 7 households owned buffalo (Part 1 Report, Table 9). Within the sampling scheme chosen, it was impossible to ensure the exclusion of buffalo owners and approximately 25% of the final non-owner sample owned buffalo.

A further sample of 20 farmers at Kaudulla was taken outside the scheme boundaries. Some 1,000 acres of Crown land beyond Stage II have been settled by squatters and further small areas are cultivated within traditional villages. Informal irrigation channels have been constructed in some areas, using drainage water from Kaudulla to irrigate a maha crop of paddy. It was thought that study of farmers in this area would expand certain dimensions observable within the scheme, such as holding size, crop combinations and intensity of cultivation. A list of farmers at Patakwewa, Migaswewa, Nikahena and Waddigawewa was therefore obtained, and stratified random samples taken to give five farmers with land alienated under the 1948 Act at Waddigwewa and fifteen from the remaining encroached land.

PADAVIYA

As with Kaudulla, an important issue in the early sampling procedures was to decide how survey resources could most usefully be deployed, given a similar system comprising Upper and Lower Main Channels within the currently developed Right Bank Irrigation network. The LMC commands an area almost twice as long as the UMC, and it is only on the former that serious water supply problems occur. Since few other differences existed between the two command areas, it was decided to select the LMC. Tract 6 at 2,097 acres of a total LMC BOP area of 8,646 acres was selected for observation of intra-tract variations in farming systems and performances. It is served by a very long distributary channel (D15) with recurrent tail end water problems. In yala, water is supplied only to the top end of Tract 6, farmers at the tail end cultivating a part-share of the plots that do receive it ('bethma' system). Twenty paddy allotments were selected from the 76 most closely adjacent to the top end, and 20 from the 91 at the tail end.

Tract 2 was selected for study as the area closest to the irrigation head works (Tract 1, at only 123 acres on the BOP was rejected as too small to yield adequately representative results). Within the 453 (BOP) acres of paddy under Tract 2, some slight differences in cropping calendar and cultivation practices were observed. It was therefore decided to stratify the sample between top and tail ends, as with Tract 6, and so 11 allotments were chosen at random from the 38 adjacent to the top end, and 9 from the 25 at the tail end.

At the lower end of the LMC, Tract 12 was selected as an area appropriate to yield observations on farm decisions taken under water availability constraints. Of the 303 allotments demarcated under the BOP, 118 have been abandoned, giving an irrigated area of some 555 acres in maha only. In yala, as at the tail end of Tract 6 and of several others, farmers share irrigated allotments higher up the scheme under the bethma system.

(B) Owners

i) Sampling Criteria:

A major criterion in selecting owners of farm power for study was that adequate representation should be obtained of the use of each power type, 4-wheel tractors, 2-wheel tractors and buffalo, at each location.

Absolute sample sizes were thus roughly equal for each power type within each of the locations, and within the maximum number of owners (70) at each location that it was felt possible to handle with the available study resources.

The attempt was also made, however, to stratify within these sample sizes in order to sample disproportionately heavily those ownership characteristics which were thought *a priori* likely to have a bearing on the composition of power use and its intensity. These were:

(1) the extent to which several power sources, of the same or different types, were concentrated into the hands of a single owner;
(2) the main occupation (in terms of relative contribution to aggregate net income) of the owner.

ii) Sampling Frame:

The main sampling frame was obtained in identical fashion at each of the three locations. Staff of the Agriculture Department (at Uda Walawe, of the RVDB) were requested to assemble lists of the ownership of each power type, and to distinguish between allottee-owners and non-allottee-owners.

For reasons of logistics, it was impossible to sample directly from these lists: they had to be split into sub-locations, and only owners living in those locations close to where investigators could be accommodated and supervised could be selected. Inevitably, this led to the same broad clustering as has been described above for the non-owner samples.

The geographical locations of owners that were selected in this process were as follows:-

1. Uda Walawe RB : (Tracts 2-7
(Embilipitiya Town
(Tracts 15-19
(Tracts 10, 11A
(Certain owners residing off-scheme

2. Kaudulla : (Stage I only
(Minneriya

3. Padaviya : (Tract 2
(Padaviya Town
(Tracts 7-9
(Tract E
Tracts 10-12
Pulmoddai

Three aspects of this listing require further explanation:

a) At Uda Walawe, the fact that very few 4wt were owned by allottee or non-allottee residents on the scheme in Tracts 15-19 prompted two courses of action: 3 additional owners were selected from the lists prepared for the adjacent tracts (10, 11A), and second the movement of power into some parts of these schemes at peak periods claimed by scheme staff to be of considerable importance, was covered by selecting 9 owners from a list of those known by scheme staff to bring their power onto the scheme.

b) At Kaudulla, insufficient numbers of 4wt to meet sample requirements were recorded on the scheme, but some hiring out from neighbouring Minneriya was reported. It was therefore decided to draw a sample also from Stage IV of Minneriya, which borders on Kaudulla. A full listing of power from Minneriya was therefore obtained (Part 1 Report, Table 11).

c) At Padaviya, preliminary investigations of power ownership in areas adjacent to the scheme revealed a high density of 4wt at Pulmoddai. A list prepared by the relevant cultivation officer revealed a total of 26 tractors owned there. Since the population of 4wt at Padaviya itself was known already to be high relative to the two other study locations it was thought worthwhile to investigate the use of tractors there, and 10 owners were selected from the list provided.

The geographical clustering procedure described above resulted in a reduced sample frame of owners. The size of the reduction was as follows:

TABLE A.1.1:SPATIAL CLUSTERING IN SAMPLE SELECTION

		Initial Sampling Frame	Reduced Sampling Frame	% Frame Retained ($\frac{\text{reduced}}{\text{initial}}$ X 100)
UDA WALAWE:	4wt	57	23	40.4
	2wt	339	122	36.0
	Buffalo	198	59	29.8
KAUDULLA:	4wt	18	14	77.8
	2wt	49	34	69.4
	Buffalo	1,094	498	45.5
PADAVIYA:	4wt	150	62	41.3
	2wt	137	68	49.6
	Buffalo	610	404	66.2

Note: 1. To avoid double counting, those owners with several power sources have been entered only in their 'highest horsepower' category, the assumed horsepower ranking being: 4wt, 2wt, Buffalo.

At Padaviya and Uda Walawe, whilst the percentage reduction was, on the whole, well over 50%, the existence of large initial populations meant that the absolute size of the reduced sample remained high. At Kaudulla, with its smaller tractor populations, the reverse was true. Therefore, it was thought necessary to supplement the 4wt populations at Kaudulla by a part of the population at neighbouring Minneriya (see above).

It was felt, on balance, that little in the way of representativeness would be lost by this geographical clustering, whilst much would be gained in terms of logistic simplicity. Perhaps most important, the clustering procedure still permits the effects on power use patterns of water availability and the varying resource endowments of nearby potential hirers to be observed in the samples, since these are in most cases now divided between top and bottom end of the schemes.

After completion of the geographical clustering described above, further weighting was introduced in the attempt to give adequate coverage to sample characteristics which could be expected to demonstrate whether the composition of power use and its intensity varies among:

(i) owners having single and multiple power units,
(ii) owners having differing main occupations.

Methodological issues in this weighting are discussed in the Part 1 Report, Chapter 2.2 and Appendix IV.

4. Field Investigators and Data Collection

Field investigators, generally having two passes at GCE Advanced Level, were recruited in sufficient numbers to permit one investigator to be allocated to 20 owners or non-owners.

Following the selection and brief but intensive training of the team of field investigators, their activities at each of the three study locations were monitored by supervisory visits conducted every fortnight by research staff. Continued visits of this frequency were felt necessary to keep research staff abreast of developments in the field, to ensure greater reliability of data collection to provide effective and sustained liaison between the field and the Colombo office, and to deal with the inevitable difficulties which arise over codes, schedule entries, changes in the characteristics of the sample members, equipment requirements and so on.

The principal function of these visits was manual examination of completed schedules from each investigator for consistency and accuracy. While cross checks on these factors were built into the schedule design, additional checks were provided by a variety of means: comparison with other investigators' schedules; general conversation with the gathered group of investigators, with local Agricultural Instructors and Cultivation Officers, with farmers and owners, and other officials employed on the schemes; visual observation of current agricultural operations on various tracts and stages of each scheme; and the knowledge of what is happening in the other study locations. A second scrutiny of schedules was provided in the office during the data tabulation exercise. Errors in codes and schedule entries identified at the initial examination on site were rectified at once, while those picked up during data tabulation were referred back to the investigators concerned. Any alterations and amendments to codes, schedule design or procedure were published regularly and made known to all investigators.

Members of the study team shared the task of conducting the weekly schedule of supervisory visits to the field, taking with them supplies of stationary, blank schedules and other equipment required for the performance of their work. The two week cycle of visits designed to cover Padaviya and Kaudulla, in one visit (due to their relative proximity) and

Uda Walawe in another, was adhered to from the commencement of the field survey. A number of 'surprise' visits were made at each location in an attempt to guard against investigator absenteeism and data collection inadequacies.

Field investigators gathered information by interviewing their sample members two or three times a week, depending on the accessibility of the owner or farmer. Replies to the question routine were entered on to specially designed field note schedules before the final survey schedule was completed. In this manner a copy of the data was maintained for future use should any schedule become mislaid or prove incomplete. Sampled owners of draught power willing to do so were issued with note books in which to write down daily records of the nature of work performed, time taken, type of payment (if any) and so on. This source of information was used in addition to the regular interview.

It was natural that over a period of time investigators should become familiar with their sample members and less of a cause for suspicion in their area. They were aided in this by lodging in houses belonging to local families and/or taking their meals at neighbourhood eating places. Besides being questioned on matters relating to their completed schedules, investigators were encouraged to exploit this familiarity with the local community and furnish research staff with information or gossip relevant to the broad area of the study, which might provide ideas for new lines of investigation. This form of initiative was possessed to varying extents by the field investigators. However, by encouraging an active interest in the study and keeping them up to date with research progress the investigators were made aware of their value to the success of the project.

On our own part, the research staff attempted to visit personally as many of the sample owners and non-owners as possible. Each sample member had previously received official letters written in Sinhala from the appropriate Government Agent (or assistant G.A.) and the Director of ARTI explaining the nature of the intended survey and requesting co-operation. Further letters eliciting continued support were sent out in January, 1980. Personal follow-up visits provided the opportunity for expressing our gratitude for their participation and simultaneously removed (in most cases) suspicion of our investigators' curiosity. We emphasised the confidentiality of the information sought and stressed that none of us represented the Government. Predictably, owners proved to be the most suspicious of the survey questions, particularly where these related to assets and extent of land controlled. By concentrating personal visits on this group the research team was able to overcome many of their doubts. The support received by local scheme officials familiar with the community in introducing the investigators to the sample had much the same effect.

The design of data collection schedules

At an early stage in the study it was decided that it would be impracticable to apply a single set of questionnaires or data collection schedules across all samples. Separate schedules would be necessary for data collected from non-owners and from owners. The only exceptions lay in the harvest details schedule and the sociology questionnaire which with minor differences were applied to both samples.

Most of the schedules were administered continuously through maha and yala seasons; others (acreages and harvests) were season-specific. All schedules were either pre-coded for direct data transfer to computer or

(in the case of a few) were formatted to allow for easy post-coding. The introduction of schedules was staggered slightly to give investigators adequate opportunity to familiarise themselves with the samples and surroundings.

For the owners' schedules, a decision was made before the survey started on the likely degree of sensitivity attached particularly to questions on income. It was decided that if the attempt was made to obtain from owners details of the payments they obtained from hiring out their farm power, they might tend to distort both the income and the stated use-levels in order to present an underestimate of their earnings. Accordingly, it was decided to rely on non-owners for this information, and to collect from owners only those data relating to use-levels and method (not amount) of payment.

The implementation of schedules D and E was faced with similar problems. Initially investigators were asked to try as tactfully as possible to administer both of these to the entire owners' sample. The attempt was closely monitored by the researchers. It quickly became apparent that some owners were reluctant to disclose information under both headings. The implementation of these schedules was then revised to include only those owners who had expressed willingness to provide the necessary data. This amounted to somewhat less than half of the total sample.

A summary of the schedules applied to owners and to farmers is given below. Samples schedules are given in Part 1 Report, Appendix IX.

TABLE A.1.2: SCHEDULES ADMINISTERED TO OWNER SAMPLES

Schedule Type	Data Frequency	Designation	Start of Implementation
Buffalo owners - record of work done	daily	Schedule A	August, 1979
Tractor owners - record of work done	daily	Schedule A_1	August, 1979
Buffalo owners - purchases & sales of related items	monthly	Schedule A_0	September, 1979
Tractor owners - record of maintenance, fuel & repair	weekly	Schedule A_{10}	August, 1979
Buffalo owners - opening stock	single-shot	Schedule B	August, 1979
Tractor owners - opening stock	"	Schedule B_1	August, 1979
Buffalo owners - herd changes	monthly	Schedule C	September, 1979
Buffalo and Tractor owners - farming activities	monthly	Schedule D	September, 1979
Buffalo and Tractor owners - Financial transactions	monthly	Schedule E	September, 1979
Buffalo and Tractor owners - sociology questionnaire	single-shot		March - April, 1980
Buffalo and Tractor owners - crop acreages	"	Schedule 5A	March - April, 1980
Buffalo and Tractor owners - harvest details	"	Schedule 6	March - April, 1980
Buffalo owners - closing stock	"	Schedule Z	September, 1980
Tractor owners - closing stock	"	Schedule Z_1	September, 1980.

TABLE A.1.3: SCHEDULES ADMINISTERED TO NON-OWNERS SAMPLES

Schedule Type	Data Frequency	Designation	Start of Implementation
Physical farm inputs	weekly	Schedule 1	August, 1979
Financial transactions	weekly	Schedule 2	August, 1979
Start of season - status of cultivation	single-shot	Schedule 3	August, 1979
Dates on which farmers obtain water	daily	Schedule 4	October, 1979
Survey of land resources	single-shot	Schedule 5	February-March, 1980
Harvest details	"	Schedule 6	March-April, 1980
Sociology questionnaire	"		March-April, 1980
Supplementary questions on source of water supply	"		May, 1980

APPENDIX 2: A REVISED CALCULATION OF ESTIMATED TILLAGE CAPACITY OF THE FARM POWER STOCK OVER TIME

Calculations in Chapter 2 (Figure 2.1), based on conventional assumptions regarding tractor and buffalo work-rates, suggested that the farm power stock had been more than adequate to plough the national asweddumised acreage in maha - the main season, and therefore the one in which draught power constraints are likely to be most evident. The tillage potential was also observed to have improved slightly since 1961.

Estimates of this kind are fraught with methodological problems - those of estimating the proportion of each component of the farm power stock that is available for field work, of applying appropriate work rates and of deciding on a use-intensity of the farm power stock within an assumed time period for land preparation.

Some refinement to the assumptions can be made as a result of our field survey. In particular, we can now apply observed rates of work output for the respective power types, with the caveat discussed in Chapter 3.2 that they may represent some underestimate. Substituting the work-rates arising from our data of 0.15 acres/day/buffalo pair, 0.58 acres/day for 2wt and 1.5 acres/day for 4wt (for full land preparation) for the commonly held sssumptions of 0.3, 0.67 and 2.0 acres/day respectively, we arrive at revised calculations of tillage potential in relation to the national asweddumised acreage presented in Table A.2.1.

The ratios of tillage potential to asweddumised acreage indicated here are substantially smaller than those presented in Table 2.1.1. They are likely to represent the more realistic of the two assessments of the area that can be tilled within a 32-day period from the available draught stock. Significantly, there appears to have been a substantially greater improvement in the ratio since 1961 under these revised estimates, suggesting that the performance rate of buffalo in relation to that of tractors had been overestimated in the previous calculations, so that the relatively higher component of buffalo in the overall farm power stock in the earlier part of the period inflated the tillage potential particularly for that period.

Even under these lower work rate assumptions, there is no apparent reason to suppose that the farm power stock is inadequate for an acceptably rapid tilling of the asweddumised acreage.

TABLE A.2.1: REVISED CALCULATIONS OF TILLAGE POTENTIAL IN RELATION TO NATIONAL ASWEDDUMISED ACREAGE

Year	Maha Tillage Potential (acres) of: 2wt	Buffalo	4wt	Total	Ratio of Tillage Potential to Asweddumised Area	Asweddumised Acreage
1961		741120	34644	775764	0.66	1180018
1962		640320	73083	713403	0.60	1197085
1963		817920	101157	919077	0.75	1230441
1964		961920	118970	1080890	0.87	1249968
1965		1008960	129511	1138471	0.89	1272673
1966		798720	167985	966705	0.73	1323317
1967		734400	230949	965349	0.73	1327452
1968		751680	270653	1022333	0.76	1349069
1969		734400	334249	1068649	0.77	1385510
1970		706560	377220	1083780	0.77	1405467
1971		701760	386847	1088607	0.73	1419185
1972		718080	422194	1140274	0.79	1448393
1973	21309	682560	427640	1131509	0.79	1438874
1974	51606	706560	434386	1192552	0.80	1479733
1975	69600	785280	441414	1296294	0.84	1516610
1976	82278	819840	452306	1354424	0.87	1535159
1977	100060	764160	468117	1332337	0.81	1588543
1978	137005	781440	557011	1475456	0.90	1625474
1979	170033	810240	654970	1635243	0.97	1614012

Notes:

1. Estimates of asweddumised area are as for Figure 2.1 . and of the rates of availability for cultivation and length of cultivation period from Table 2.1.2.

Appendix 2.1:

Policy Options in Sri Lanka

Self-sufficiency in the provision of major food items has long been a cornerstone of development policy in Sri Lanka. It is this goal which has underlain the extensive re-habilitation of major rice irrigation schemes since the 1930s (e.g. Farmer, 1957, Ch.5-7; World Bank, 1976; Asian Development Bank, 1977) the plans to develop non-paddy food crops (e.g. FAO/World Bank, 1978) and is central to the country's most ambitious development effort, the Mahaweli river diversion project (UNDP/FAO, 1969).

Several adverse trends in Sri Lanka's external trade account make this goal imperative: some 70% of the value of exports derives from primarily estate-grown crops, the production of which has expanded only slowly in recent years; furthermore international prices of a major export (tea) have recently failed to keep pace with inflation. At the same time, a population growth rate of approximately 2% p.a. (Central Bank, 1979) and an erratic performance in local food production have prolonged the need for high levels of food imports (Table 2.4.1).

Against this background, as the socio-economic indicators in Table 1.2.2. suggest, Sri Lanka remains comparatively well-endowed for economic expansion. Her prospects are best reviewed in the context of the main agro-climatic zones (Map 1). Whilst resource pressures are high in the Wet Zone (e.g. population densities exceed 1,000 persons/sq. mile as against 233/sq. mile in the Dry Zone[1]) there remains an estimated 2.5 million acres of land in the Dry Zone with potential for cultivation under the range of annual crops currently grown in the small farm sector. (FAO/UNDP, op. cit.) Much of this land has potential for at least partial irrigation: heavy rainfall in the Central Highlands is drained radially; several rivers are perennial, and the Dry Zone topography is gently undulating, offering ample scope for gravity irrigation systems.

It is within this context that government policies have been designed and implemented to increase the amount and diversity of agricultural production, chiefly through development of irrigated smallholder settlement in the Dry Zone. This policy, serving the twin objectives of food production and population re-settlement, relies for its execution on both a measure of direct intervention and a degree of reliance on farmers' responses to market forces.

With recent exceptions,[2] the thrust of development policy has been towards the rehabilitation of ancient major irrigation schemes in the Dry Zone. Approximately 180 major[3] irrigation schemes currently serve some 600,000 acres in the Dry Zone, with an annual cropping intensity of 145%. They constitute over one third of the asweddumised[4] area in the country, and three quarters of asweddumised land in the Dry Zone.

[1] Based on Census and Statistics Department Projections for 1981 at 2.1% average annual growth rate.

[2] See for instance, World Bank, 1981; CIDA, 1976, and the recent upsurge in implementation of Integrated Rural Development Projects.

[3] i.e. with a command area of at least 200 acres.

[4] See Glossary.

TABLE A.2.1.1: SRI LANKA - RECENT TRENDS IN FOOD PRODUCTION AND IMPORTS

		1978	1979	1980
		(% of value of imports)		
IMPORTS	Food and drink	28	21	18
	Petroleum	16	17	24
	Fertiliser	2	3	4
	Investment goods	23	24	24
	Other	31	35	30
		(Rs. million in respective years)		
VALUE OF IMPORTS[1]		14,687	22,560	33,637
		(% of G N P)		
PRODUCTION	Agriculture	24.1	23.1	22.4
	Paddy only	6.4	6.2	6.5
	Manufacturing	14.7	14.5	13.8
	Construction and services	53.2	54.5	56.2
		(Rs. million in respective years)		
GNP at Constant 1970 prices		17,211	18,389	19,405

[1] These figures reflect both price increases and changes in volume. Between 1979 and 1980, the former rose by 43%, the latter by 14%.

SOURCE: Central Bank of Ceylon, Annual Report, 1980, Colombo, p.54.

TABLE A.2.1.2: KEY ECONOMIC INDICATORS - SRI LANKA AND NEIGHBOURING COUNTRIES

Reference	Year	Sri Lanka	Bangladesh	India	Malaysia	Nepal
Agriculture/GDP (%)	1979	25.0	50.7	45.9	24.0	62.3
Manufacturing/GDP (%)	1979	14.4	10.4	15.3	19.8	7.9
Daily per capita protein supply (grams)	1978	41.5	39.3	49.0	56.9	47.7
Daily per capita calorie supply (calorie)	1978	2,055	1,813	2,034	2,610	2,002
Terms of trade (1970=100)	1979	68.6	-	93.4	104.0	-
Index of Agricultural production (1969=100)	1979	115	112	117	141	112
Literacy Rate (%)	Latest Year	79	22	34	58	19
Life expectancy (years)	1977	69	47	51	67	45
Infant mortality (per 1,000 live births)	Latest Year	42	130	131	32	104

SOURCE: "Socio-economic data, Sri Lanka", Statistics Department of the Central Bank of Ceylon, Colombo, 1980.

The organisation of agricultural production on large irrigation schemes is a microcosm of the dual forces of central authority and individual autonomy by which the mixed economy is governed. There, as with many aspects of national economic development, potential conflict exists between the State's action to further what it interprets as the common good, and the individual's freedom to make his own decisions within the framework of constraints he faces. In large-scale irrigation, the most basic potential conflict exists between the organisation of stored water use, in which decisions at least at the higher levels, are executed centrally, and the organisation of production at the farm level, which incorporates a requirement for irrigation water, but in which individual settlers enjoy a degree of autonomy.

Policy is currently conditioned by an awareness that in aggregate, inadequate water is available for the land that could potentially be brought under irrigation command. At the national level, water is a scarce resource, yet, in recent times at least, no charge has been made to the farmer for its use (nor are fines levied for its misuse).[1] Consequently, according to local circumstances, the farmer may regard irrigation water as a free good or, at best, as a common property resource.

There is much evidence to suggest that from the early years of its introduction in Sri Lanka, mechanisation was viewed by politicians and officials as an innovation which could contribute strongly to increased food production, initially through the clearing and levelling of land to pave the way for new colonisation schemes. After this initial phase it was expected to raise the efficiency of paddy production on the new irrigated settlements by more rapid land preparation, and, in particular, better synchronisation of cultivation. These, respectively, would permit an earlier start to the season, making better use of initial monsoon rains which would otherwise run off the paddy fields, and would reduce the consumption of stored water through a reduced need to continue end-of-season water issues to cater for the slower farmers.

Many contemporary reports of statements by officials and politicians testify to the perceived importance of mechanisation in increasing food production through relieving labour bottlenecks and improving the efficiency of water-use during its introductory phase. They also, however, indicate an inadequate grasp of precisely how the services of such a prestigious technology as the 4wt could be translated into practical improvements in the paddy field, and errors and inconsistencies of argument are abundant.

Early political statements in favour of 4wt include a speech by Dr. N. M. Perera, then leader of the LSSP,[2] at an annual YMCA convention, in which he linked the need for 4wt with national goals of food self-sufficiency (Ceylon Daily News - henceforth CDN - 11.2.46). Others, e.g. by the Prime Minister, D. S. Senanayake, in Peradeniya, stressed that the application of mechanisation to small-scale farming was still in an experimental stage, and technologies would have to be sought which were

[1] Whilst legislation does provide for fines to be imposed on those contravening aspects of the Irrigation Ordinance, implementation of the legislation is cumbersome, and prosecution correspondingly rare (Moore, 1980a).

[2] Lanka Sama Samaja Party (a Sri Lanka Socialist Party not aligned to the main communist power blocs).

both efficient and within the (financial and technical) capacity of the cultivator (CDN, 15.11.49). Official reports, for instance of the Director of Agriculture for 1944 and of the Director of Irrigation for 1945, (CDN, 20.2.46 and 28.10.46 respectively) stressed the significant contribution to efficiency with 4wt had made in the timing of tillage on experimental stations and in accelerating irrigation construction works. Whilst tractors issued to these Departments had performed tilling for small farmers at a nominal (or zero) charge as part of the food production drive (CDN, 28.10.46), officials took a cautious approach, the Director of Irrigation stressing the limitations to the performance of 4wt that would be imposed by the small size of liyaddes[1] (CDN, 28.10.46) and the Director of Agriculture stating that it still remained to be established whether 4wt offered, under Sri Lankan paddy farming conditions, the benefits that were claimed for them elsewhere. Nor was it clear that they would be more economic than animal draught, given the value of by-products obtainable from the latter (speech to Kandy Planters' Association - CDN, 25.6.48).

Tractors were, however, the subject of several publicity efforts at about this time, none of which made a serious attempt to demonstrate precisely how they would improve paddy farming efficiency. These included the collaborative showing by the United States Information Service and the United Tractor and Equipment Co. Ltd. of Colombo, of films on mechanised farming in the USA (especially in the Tennessee Valley). Guests of honour were the Ministers of Agriculture and of Finance, (CDN, 6.1.48). Similarly, sweeping statements were made by visiting officials that tractors would be more economic than conventional methods in paddy cultivation (e.g. C. Higgs, Chairman of the Machinery Committee of the British National Farmers' Union to the Central Board of Agriculture - CDN, 2.2.46) and by overseas correspondents that Sri Lanka had much to learn from successful experiments with tractors elsewhere (CDN, 1.4.48). Others were more circumspect: H. W. Jack, Agricultural Adviser to the Governor General of British South East Asia, after a two-week survey of Sri Lanka's agricultural settlements, stressed the fact that mechanisation was still in an experimental stage in S. E. Asia, and much remained to be learned (CDN, 29.6.48).

In this early period, frequent references were, however, also made to the need to develop animal draught resources, particularly in view of the spatial variations in their density per unit of agricultural land. The Gal Oya Development Board, for instance, is reported to have enquired about the possibility of re-locating 2,500 buffalo from the North Central Province (NCP) to Gal Oya to permit initial cultivations by newly-settled families there (CDN, 22.2.51). Large herds of unutilised, semi-wild buffalo could be seen in the catchment areas of the Polonnaruwa tanks. The response to this request was favourable, there being enough surplus draught animals in the NCP (CDN, 24.2.51) and elsewhere (CDN, 11.5.51) to meet the annual Gal Oya requirement of 2,500 (CDN, 11.5.51)[2].

Politicians, however, appear to have preferred to link their names with tractorisation. What was claimed to have been the first paddy-field ploughing in Sabaragamuwa Province was attended by the Minister of Agriculture (CDN, 3.7.51). The same Minister took a major initiative to promote the tractoriations of paddy farming at about the same time. He

[1] See Glossary.

[2] Subsequently reported as 5,000 annually (CDN, 3.7.52).

instructed all co-operative societies owning tractors to carry out ploughing for small farmers, issued a similar order to the Department of Agriculture, and sought the co-operation of the Departments of Irrigation and of Land Development in making tractors available for ploughing. In all cases only nominal charges were to be levied. He referred particularly to shortages of labour in the Dry Zone, attributing them to a desire on the part of potential labourers to become owner-cultivators and to withdraw from the labour market (CDN, 11.5.51). During the construction of Gal Oya irrigation scheme settlers could obtain 7-9 acres of land each (CDN, 14.10.52), and were so heavily involved with their own crops at peak seasons that they could not provide their own farm labour inputs from family sources, let along work as labourers for others.[1] Nor was it immediately apparent how the use of tractors would relieve a Dry Zone labour bottleneck in the initial harvesting/threshing period (CDN, 13.3.52), since no specific tractor-powered harvesting technology had been devised, and, in any case, the aggregate amount of labour required for threshing by 4wt is barely lower than that for buffalo threshing.[2]

There thus appears to have been some initial confusion in identifying the precise contribution that mechanisation could make to the paddy economy. The labour shortages that mechanisation was supposed to relieve were themselves a consequence of the large size of holding allocated in official settlements. Embedded in official policy was the notion that each man should be able to cultivate his own plot of land, but this was not without ambiguity in the practical context of the peaks and troughs of activity which characterise paddy cultivation. An allotment small enough for family labour to manage at peak periods would leave them severely underemployed at other times, and would probably be so small as to provide a barely adequate living. On the other hand, allotments of 7-9 acres would certainly require substantial amounts of hired labour in peak periods, for which no provision was made. Similarly, confusion seems to have existed between the speed at which a tractor can perform operations on a given small farm - this is certainly higher than the performance of a pair of buffalo - and the aggregate time necessary to cultivate an entire irrigation scheme (or major tracts of a scheme) which is the important criterion for synchronisation of cropping and, therefore, for water savings. The possibility of achieving a performance rate equivalent to that of a tractor by increasing the number of units of buffalo draught was not explicitly considered, although for the majority of circumstances there appear to have been no grounds against such an alternative.[3]

[1] Reference to Appendix 4, Tables A4.1.1-2 makes this immediately apparent: even with paddy holdings in the range of 2-3 acres some 40% of all labour has to be hired. Further, whilst the notion that hired labour shortages could be compensated by tractor use may have been relevant to the difficult conditions of Gal Oya in its early stages, when farm families had to supply high labour inputs simply to survive, it does not appear to be the case for current conditions: an increase in mechanisation from buffalo to tractors in land preparation, levelling and threshing reduces overall labour input by a small amount relative to a change from manual to animal cultivation, and of this, by far the majority comprises a reduction in family labour inputs (Chapter 4).

[2] Tables 4.1.1.-4.1.2.

[3] The exception to this is in the tilling of hard land at the end of a long dry period, which is feasible by tractor but not usually by animal draught. Even here, there is scope for ploughing by animal on residual moisture immediately after harvest, though it has received little consideration then or at any subsequent time.

Tractorisation, however, continued to be associated with modernity and efficiency, and the Department of Agriculture set up tractor hire units in Nalanda (CDN, 17.4.52) and subsequently in Hikaweratiya (CDN, 28.11.52). Statements were made by the Minister of Agriculture in favour of increased use of tractors to bring additional land under cultivation (CDN, 22.8.52) and a plan to introduce 1,000 tractors for distribution to hiring stations in the Northern, North-West and North Central Provinces was eventually conceived (CDN, 18.10.52). The water-saving role of early, synchronised cultivation was stressed in the provision of additional tractors for hiring to farmers by the co-operative societies in Kurunegala (CDN, 28.11.52).

Perhaps the culmination of this initial stage of tractorisation was the provision by the Australian Government of a grant of 175 tractors for hiring to small farmers (CDN, 21.3.53). The bulk of these were located at the Kangaroo Tractor Station (Department of Agriculture) in Anuradhapura. They were plagued by shortages of spare parts and of skilled mechanics from the start, and in their first year's work achieved an average of only 17 acres of ploughing per tractor (calculated from CDN, 1.7.54).

The mid-1950s saw an increase in the role of foreign aid donors in supplying tractors (CDN, 27.2.58) and in the sales and training activities of local agents of large tractor companies (CDN, 4.6.55, 8.9.58). Occasional anxieties were expressed by politicians at the apparent inability of government agencies to maintain the equipment under their charge (c.f. comments by the Minister of Food on the derelict equipment, including tractors, at Gal Oya - CDN, 25.7.57), but the atmosphere on the whole was one of unrestrained official support for small-farm tractorisation, as exemplified in the waiving of taxes and duties payable on tractors and diesel fuel by the Minister of Finance, to encourage mechanised cultivation in the country (CDN, 7.3.57).

Appendix 2.2: Availability for Farm Work in Relation to Family Size

TABLE A.2.2.1: MEAN SIZE OF FAMILY WORKFORCE AND AVAILABILITY FOR FARM WORK

NON-OWNER SAMPLE	UDA WALAWE Adult Equivalents Size of Work-force	Avail-ability	% Avail-ability	KAUDULLA Adult Equivalents Size of Work-force	Avail-ability	% Avail-ability	PADAVIYA Adult Equivalents Size of Work-force	Avail-ability	% Avail-ability	ALL LOCATIONS Adult Equivalents Size of Work-force	Avail-ability	% Avail-ability
Top	4.60 (0.41) (20)	2.66 (0.24) (20)	57.8	6.17 (0.47) (18)	3.20 (0.33) (18)	51.9	4.85 (2.61 (20)	2.20 (0.24) (20)	45.4			
	5.13 (0.44) (20)	2.24 (0.24) (20)	43.7	5.34 (0.44) (19)	2.72 (0.35) (19)	50.9	6.08 (0.51) (20)	2.46 (0.34) (20)	40.5			
Tail	4.05 (0.51) (19)	2.03 (0.18) (19)	50.1	5.19 (0.45) (16)	2.23 (0.29) (16)	43.0	5.78 (0.52) (20)	2.19 (0.22) (20)	37.9			
	4.71 (0.57) (17)	2.62 (0.34) (17)	55.6	3.70 (0.47) (20)	2.10 (0.28) (20)	56.8	4.23 (0.50) (20)	1.84 (0.19) (20)	43.5			
All	4.63 (0.24) (76)	2.38 (0.13) (76)	51.4	5.06 (0.25) (73)	2.56 (0.16) (73)	50.6	5.23 (0.25) (80)	2.17 (0.13) (80)	41.5	4.98 (0.14) (229)	2.37 (0.08) (229)	47.6

'But not implemented.

TABLE A.2.2.2: OWNER SAMPLE: MEAN SIZE OF FAMILY WORKFORCE AND AVAILABILITY FOR FARM WORK (SUB-SAMPLE OF OWNERS FOR WHOM FARM RECORDS WERE KEPT)

	UDA WALAWE			KAUDULLA			PADAVIYA			ALL LOCATIONS		
	Adult Equivalents Size of Work-force	Avail-ability	% Avail-ability	Adult Equivalents Size of Work-force	Avail-ability	% Avail-ability	Adult Equivalents Size of Work-force	Avail-ability	% Avail-ability	Adult Equivalents Size of Work-force	Avail-ability	% Avail-ability
4wt Owners	6.75 (1.96) (4)	3.03 (0.52) (4)	44.9	4.80 (0.74) (5)	1.85 (0.32) (5)	38.5	4.49 (0.34) (33)	1.75 (0.23) (33)	39.0	4.74 (0.34) (42)	1.88 (0.19) (42)	39.7
2wt Owners	4.63 (0.72) (15)	1.78 (0.26) (15)	38.4	6.81 (0.79) (8)	3.07 (0.44) (8)	45.1	4.92 (0.55) (18)	2.23 (0.35) (18)	45.3	5.18 (0.40) (41)	2.22 (0.21) (41)	42.9
Buffalo Owners	4.82 (0.54) (11)	1.96 (0.28) (11)	40.7	5.92 (0.42) (12)	2.97 (0.28) (12)	50.2	5.85 (0.61) (13)	3.54 (0.91) (13)	60.5	5.56 (0.31) (36)	2.87 (0.36) (36)	51.6

TABLE A.2.2.3: OWNER SAMPLE: MEAN SIZE OF FAMILY WORKFORCE AND AVAILABILITY FOR FARM WORK (FULL OWNER SAMPLE)

4wt Owners	4.83 (0.54) (20)	1.38 (0.28) (20)	28.6	4.12 (0.35) (13)	1.37 (0.25) (13)	33.3	4.44 (0.35) (33)	1.81 (0.23) (33)	40.5	4.49 (0.31) (66)	1.58 (0.18) (66)	35.2
2wt Owners	4.35 (0.45) (26)	1.43 (0.20) (26)	32.9	5.85 (0.61) (20)	2.79 (0.26) (20)	47.7	4.80 (0.45) (23)	2.07 (0.28) (23)	43.1	4.93 (0.36) (69)	2.04 (0.22) (69)	41.4
Buffalo Owners	5.61 (0.56) (19)	2.24 (0.22) (19)	39.9	5.90 (0.29) (24)	2.93 (0.18) (24)	49.7	6.03 (0.44) (20)	3.38 (0.70) (20)	56.1	5.85 (0.24) (63)	2.86 (0.24) (63)	48.9
All Owners	4.87 (0.31) (65)	1.65 (0.14) (65)	33.9	5.48 (0.32) (57)	2.53 (0.15) (57)	46.1	4.97 (0.29) (76)	2.30 (0.18) (76)	46.3	5.08 (0.16) (198)	2.15 (0.11) (198)	42.3

NOTES TO TABLES A.2.2.1-A.2.2.3

1. In each case, standard errors and numbers of observations are given in parentheses below the means.
2. In Table A.2.2.1 and subsequent tables throughout this report in which data are disaggregated by sub-area within location, the 'Top' and 'Tail' sub-areas refer to sample stratifications designed to reflect varying availabilities of irrigation water as follows:

Uda Walawe

'Top' 2 samples at the top and tail ends of Tract 4 respectively. The commonly observed water shortages at the tail end of Tract 4 were of little consequence in our survey year, so that major performance differences between these two groups did not emerge.

'Tail' 2 samples, one in Tract 18, the other at the top end of Tract 19. Parts of both Tracts have been abandoned due to the impossibility of supplying irrigation water. Our sample farmers, drawn from those who cultivate regularly, had to rely heavily on rainfed farming.

Kaudulla

'Top' 2 samples, one drawn from the head of Tract 1, the other from the tail end. The tail end is subject to flooding in the early part of the maha season, and to water shortages in the remainder of maha and in yala.

'Tail' 2 samples, are drawn from the upper end of Tract 8, the lowest tract on the Stage I Main Channel, the other from a village just outside the scheme boundary which cultivates partly on drainage water from Stage I. At Kaudulla, conditions in the lower end of Tract 1 were observed to be more difficult than in Tract 8 during the survey year, so that many of the performance indicators discussed (Chapters 3-4) are more typical of a tail end than a top end situation.

Padaviya

'Top' 1 sample drawn from Tract 2 with representation from both top and tail ends of this long narrow Tract. One sample drawn from the top end of Tract 6.

'Tail' One sample drawn from the tail end of Tract 6. Although Tract 6 is the longest on the scheme, and water supply problems have been reported in some seasons at the tail end, these were not evident in our survey year, so that little difference in performance is to be expected between the top and tail samples from Tract 6.

NOTES TO TABLES A.2.2.1-A.2.2.3 (continued)

Padaviya 'Tail' (cont.) One sample drawn from Tract 12 in many parts of which the supply of water is irregular. Conditions are more extreme in Tracts 12A and 13, many parts of which have been abandoned or are cultivated under rainfed crops.

Further details of the sampling scheme, with maps of the location of sample farms are given in the Part 1 Report, Chapter 2 and Appendices II & IV.

3. In Tables A.2.2.1-A.2.2.3 and all other tables in which owners are classified by power type owned, the convention adopted in cases where two different types are owned by the same sample member was to allocate him into the category appropriate to the power type having the highest horsepower. An owner having both buffalo and 2wt, for instance, is treated as a 2wt owner. This convention was necessary only in a small proportion of cases.

APPENDIX 3: A NOTE ON THE CHARACTERISTICS OF FARM SURVEY DATA ANALYSED IN CHAPTER 3

A detailed description of farm survey methodology is given in the Part 1 Report (Chapter 2 and Appendix IX). Of immediate relevance for the present report is the unit of observation for collection of farm survey data from the non-owner sample (Schedule 1) and from a sub-set of the owner sample (Schedule D). The smallest unit of observation is the plot, which is defined as a field (or, not necessarily contiguous, set of fields) containing the same crop variety at approximately the same stage of growth on a homogeneous type of land. Crops are defined by their generic names (i.e. "local" maize is not distinguished from hybrid maize) with the exception that paddy (which occupied more than 90% of the land area of annual crops recorded in the survey) is described by variety, which, for convenience, was reduced to 4 categories of maturation period with a fifth category for "local" paddy. Land classifications embrace: owned/allotted lowland; rented in lowland; encroached lowland; purana (village) lowland; chena (slash and burn) highland; settled rainfed highland and settled irrigated highland.

By far the majority of paddy was grown on the first category (i.e. allotted) lowland, and it was rare for an individual farmer to grow more than one paddy variety. Thus, as far as the paddy economy is concerned, the "plot" is equivalent to the paddy farm for the majority of farmers. Since, however, a minority of farmers have more than one "plot", the overall mean size of plot is slightly lower than the overall mean size of paddy farm.

The differences in size between plots and entire paddy farms can be illustrated by reference to Table A.3.1 below, which presents, on the one hand, mean plot sizes by location and type of farm power used for land preparation, and on the other, mean lowland paddy farm sizes. Whilst, as would be expected from our discussion above, paddy farm sizes are larger than plot sizes for each individual power type, there are no cases in which the differences are significant (P=0.05).

TABLE A.3.1: NON-OWNER SAMPLE: MEAN PLOT SIZES AND MEAN LOWLAND PADDY FARM SIZES BY TYPE OF FARM POWER HIRED FOR LAND PREPARATION

Non-owners hiring in:	Mean Plot Sizes All Locations Acres Mean	S.E.	No. of Observations	Mean Paddy Farm Sizes All Locations Acres Mean	S.E.	No. of Observations
4wt	3.12	0.49	18	3.42	0.30	15
2wt	2.64	0.19	39	2.70	0.18	34
Buffalo	1.86	0.18	156	2.21	0.11	96

Whilst, therefore, our analysis of the relation between type of farm power hired in and acreage (Chapter 3.3) draws on lowland paddy farm data, which is clearly the most appropriate data set in this instance, we feel justified in conducting the remainder of the analysis on a plot-wise basis, which has a number of advantages. These include the possibility of allowing for the varying influence of paddy variety and the tenurial status of paddy land on crop output and on the input mix. It also increases the degrees of freedom in the calculation of means and standard errors.

Appendix 3.1: Size of Paddy Plot by Type of Farm Power Used

TABLE A.3.1.1: NON-OWNER SAMPLE: MEAN SIZE OF PADDY PLOT (ACRES) BY TYPE OF FARM POWER USED FOR OPERATIONS

	UDA WALAWE (Maha + Yala)			KAUDULLA (Maha + Yala)			PADAVIYA (Maha + Yala)			ALL LOCATIONS (Maha + Yala)			ALL LOCATIONS (Maha Only)		
	Acres		No.of	Acres		No.of	Acres		No.of	Acres		No.of	Acres		No.of
TILLING[1]	Mean	S.E.	Cases	Mean	S.E.	Cases	Mean	S.E.	Cases	Mean	S.E.	Cases	Mean	S.E.	Cases
by hand	0.82	0.12	14	1.11	0.22	4	1.35	0.38	4	0.97	0.11	22	1.07	0.12	18
by 4wt	0.59	0.00	1	2.63	1.15	3	3.40	0.56	14	3.12	0.49	18	3.12	0.49	18
by 2wt	2.32	0.11	40	2.63	0.44	14	3.36	0.52	5	2.48	0.14	59	2.64	0.19	39
by animal	2.06	0.11	43	-	-	-	2.33	0.26	12	2.12	0.11	55	2.17	0.15	35
by animal	-	-	-	1.46	0.07	126	1.77	0.31	15	1.51	0.07	141	1.66	0.09	101
by animal	-	-	-	-	-	-	2.32	0.26	20	2.32	0.26	20	2.32	0.26	20
by animal+4wt	-	-	-	-	-	-	1.82	0.20	17	1.82	0.20	17	1.82	0.20	17
LEVELLING															
by hand	1.77	0.15	22	1.33	0.27	11	3.58	1.06	8	2.01	0.26	41	2.16	0.45	22
by 4wt	-	-	0	3.70	0.00	1	-	-	0	3.70	0.00	1	3.70	0.00	1
by 2wt	2.29	0.11	36	3.01	1.01	6	3.38	0.00	1	2.41	0.17	43	2.56	0.26	24
by animal	2.00	0.00	1	1.66	0.07	130	2.49	0.12	66	1.94	0.07	197	2.13	0.08	159
THRESHING															
by hand	0.85	0.15	16	0.67	0.34	2	-	-	0	0.83	0.13	18	0.93	0.17	13
by 4wt	2.18	0.08	86	1.76	0.11	87	2.50	0.18	64	2.11	0.07	237	2.22	0.09	179
by animal	1.00	0.00	1	1.44	0.10	68	1.95	0.21	31	1.59	0.10	100	1.75	0.11	79
WINNOWING															
by hand	1.46	0.16	12	1.39	0.08	107	2.31	0.15	87	1.78	0.08	206	1.97	0.09	163
by 4wt	-	-	0	1.70	0.00	1	2.78	0.30	7	2.65	0.29	8	2.65	0.29	8
by 2wt	2.31	0.08	70	2.12	0.24	31	1.77	0.00	1	2.25	0.09	102	2.27	0.13	66
by machine	-	-	0	2.72	0.35	7	-	-	0	2.72	0.35	7	2.72	0.35	7

Note: 1. Operations as defined in Appendix 4.1.

TABLE A.3.1.2: OWNER SAMPLE: MEAN SIZE OF PADDY PLOT (ACRES) BY TYPE OF FARM POWER USED ON INDIVIDUAL OPERATIONS (MEAN FOR MAHA AND YALA SEASONS)

	UDA WALAWE			KAUDULLA			PADAVIYA			ALL LOCATIONS		
	Acres		No.of	Acres		No.of	Acres		No.of	Acres		No.of
TILLING[1]	Mean	S.E.	Cases	Mean	S.E.	Cases	Mean	S.E.	Cases	Mean	S.E.	Cases
by hand	-	-	0	-	-	0	0.75	0.00	1	0.75	0.00	1
by 4wt	-	-	0	3.25	0.25	2	5.88	2.14	22	5.66	1.96	24
by 2wt	2.84	0.33	17	2.20	0.26	10	4.06	0.92	19	3.20	0.41	46
by animal	2.03	0.09	18	2.05	0.18	45	2.34	0.21	18	2.13	0.14	63
LEVELLING												
by hand	2.08	0.19	6	1.50	0.00	1	2.60	0.87	3	2.18	0.27	10
by 4wt	-	-	0	2.50	0.00	1	7.23	2.80	13	6.89	2.61	14
by 2wt	3.22	0.58	9	3.04	0.23	12	3.22	0.23	6	3.14	0.22	27
by animal	-	-	0	2.12	0.17	50	2.67	0.14	29	2.53	0.25	79
THRESHING												
by hand	-	-	0	-	-	0	-	-	0	-	-	0
by 4wt	2.55	0.20	35	2.31	0.15	57	6.56	1.20	57	3.99	0.49	149
by animal	-	-	0	1.64	0.37	15	2.35	0.22	16	2.01	0.22	31
WINNOWING												
by hand	2.30	0.11	10	1.81	0.24	25	2.63	0.26	27	2.25	0.16	62
by 4wt	2.50	0.00	1	-	-	0	9.61	2.31	27	9.70	2.40	28
by 2wt	2.76	0.32	21	2.21	0.18	37	4.30	0.86	21	2.86	0.28	79
by machine	-	-	0	3.67	0.49	6	-	-	0	3.67	0.49	6

Note: 1. Operations as defined in Appendix 4.1.

Appendix: 3.2 The Relationship Between Technologies and Work Requirements Across Operations.

Much of our analysis of draught power use in Chapter 3.2 considered the techniques commonly adopted for individual operations in isolation. Thus, the time spent on land preparation ~~solely by 4wt, by 2wt~~ and by the various buffalo techniques (Table 3.2.1) was analysed independently of the impact which the various methods would have on draught power requirments for such subsequent operations as levelling, and on the labour requirments for those subsequent operations which do or do not involve draught power.

From the farmers' point of view, it would be more logical to select techniques for individual operations within the broader context of their implications for overall draught, labour and other input requirments necessary to achieve a given yield. Many aspects of the complex inter-relationships involved could usefully be investigated: if it could be shown for instance, that weed control under 4wt - tillage is poorer than with buffalo draught (as eg. Carr, 1975, has argued) then the farmer will have to trade off the advantages of 4wt tillage against higher requirements for labour and/or herbicide at a subsequent stage (and/or lower yields). For purposes of the present study, however it is possible to investigate only one aspect of these sequential patterns of resource requirments namely the inter-relationship between land preparation and levelling which seems to be the most significant for several reasons:

i) from our repeated field investigations, the wheel action of 4wt in tilling appears to churn the soil frequently causing deep ruts, which may require heavy labour inputs for levelling;
ii) at the opposite end of the spectrum the use of animals for trampling ('mudding') the soil seems to leave a relatively even crop-free surface on paddy fields, which appears likely to require little levelling;
iii) under widely-practised systems of mudland tillage, paddy fields are allowed to remain under standing water from the first ploughing to seeding and thereafter until shortly before harvesting which greatly inhibits weed growth. At our study locations these conditions applied equally across all power types, so that difference in weed growth (and the requirement for weed control) are unlikely to be observed;
iv) differences in the quality of such other operations as threshing according to the power type used may require varying allocations of time to winnowing. Such differences are, however, thought to be small, and the time spent on winnowing is, in any case heavily dependent on such locally variable (and unquantified) factors as windspeed that no causal relationships are likely to be detectable.

In Table A 3.2.1 we present the labour and farm power requirements both for land preparation and levelling by the various methods of land preparation defined in Chapter 3.2 The pattern which emerges is interesting, particularly within the animal draught methods. The 'mudding' technique requires substantially lower animal inputs (and slightly lower labour inputs) for levelling than do the other two methods, the labour and draught requirement being highest for animal levelling when preceded by buffalo ploughing. This corresponds with our observations regarding the fine tilth and relatively level field surfaces produced by buffalo mudding. This method of land preparation, however, remains a relatively inefficient one, requiring 22% more animal time and 11% more labour in land preparation

and levelling combined than do methods relying on the use of ploughs. As discussed elsewhere (Chapter 3.2), its advantages are peculiar to those areas with 'boggy' soils which churn adequately beneath the hoof action, and to buffalo ownership patterns involving large individual herds within which a sub-division into pairs, the harnessing to ploughs and the separate hiring out of individual pairs would be costly to the owner through its requirement of substantial extra labour resources.

The patterns of resource use in levelling following tractor ploughing are less easy to interpret. Both 4wt and 2wt ploughing are followed by levelling which relied on combinations of tractor and animal power. The use of tractors contributes to the lower labour requirements for levelling, and to low buffalo requirements (though these are not quite as low as for levelling preceded by buffalo mudding). There is, however, certainly no evidence that 4wt ploughing requires disproportionately heavy inputs of labour or draught resources for levelling.

Whilst the resource use patterns over combined land preparation and levelling operations exhibit some variation in the directions predicted, the differences in labour and draught use for levelling according to the method of land preparation are, on the whole, small, and compensate only a small part of the larger differences observed in labour and draught requirements for land preparation.

TABLE A.3.2.1: INPUTS OF LABOUR AND FARM POWER FOR LEVELLING FOLLOWING LAND PREPARATION BY VARIOUS METHODS (MEANS OVER POOLED DATA FOR MAHA AND YALA)

Method of Land Preparation[1]	No.of Cases	Inputs for Land Preparation (hrs/ac)			Inputs for Levelling (hrs/ac)			Inputs for both Operations Combined (hrs/ac)		
		Labour	Tractor	Buffalo Pair	Labour	Tractor	Buffalo Pair	Labour	Tractor	Buffalo Pair
By hand	22	296.2	-	-	9.0	-	-	305.2	-	-
By 4wt	18	106.3	5.3	-	7.8	0.3	4.6	114.1	5.6	4.6
By 2wt	59	109.3	14.0	-	10.8	3.0[2]	4.4	120.1	17.0	4.4
By buffalo	55	178.5	-	97.2	18.0	-	3.6	196.5	-	100.8
By buffalo	141	145.9	-	67.7	30.3	-	15.0	176.2	-	82.7
By buffalo	20	132.4	-	122.0	21.8	-	13.8	154.2	-	135.8
By buffalo	17	138.7	5.0	72.8	12.8	2.9	6.6	151.5	7.9	79.4

Notes:

1. Methods of land preparation by buffalo are as defined in Appendix 4.1. In descending sequence in Table A.3.2.1 above, they are: 'mudding', the use of ploughs; the combination of mudding and ploughing; the combination of 4wt and buffalo.
2. 2wt - all other tractor inputs in this column are 4wt.

Appendix 3.3: Work Rates by Power Type - An Alternative Estimate

TABLE 3.3.1: WORK RATES BY POWER TYPE AND OPERATIONS CALCULATED FROM DATA ON FARM POWER USED PROVIDED BY OWNERS

	UDA WALAWE			KAUDULLA			PADAVIYA		
	Hrs/Acre			Hrs/Acre			Hrs/Acre		
	Mean	S.E.	No. of Observations	Mean	S.E.	No. of Observations	Mean	S.E.	No. of Observations
4wt									
First Ploughing	3.69	0.33	124	2.41	0.21	136	2.15	0.05	1114
Second Ploughing	3.48	0.59	36	3.08	0.27	127	2.10	0.07	691
Ploughing Total	7.17			5.49			4.25		
Levelling	0	0	0	0	0	0	1.82	0.16	118
Threshing	1.45	0.04	347	.12	0.03	1,259	1.98	0.05	1,217
Winnowing	0.92	0.35	8	1.60	0.54	9	1.62	0.10	269
2wt									
First Ploughing	6.67	0.36	507	9.07	0.49	264	8.55	0.30	534
Second Ploughing	5.44	0.35	381	8.29	0.44	273	9.10	0.42	308
Ploughing Total	12.11			17.36			17.65		
Levelling	4.50	0.41	113	7.48	0.62	145	12.48	1.67	54
Threshing	-	-	-	-	-	-	-	-	-
Winnowing	3.59	0.18	219	2.98	0.15	259	2.91	0.29	100
Buffalo									
First Ploughing	44.53	1.24	742	30.76	0.66	669	32.01	1.64	310
Second Ploughing	34.34	1.43	434	10.45	0.72	546	48.37	2.43	310
Ploughing Total	78.87			40.21			80.38		
Levelling	24.46	3.18	6	14.57	0.56	478	35.27	2.12	258
Threshing	-	-	-	41.33	4.94	70	30.03	1.94	194

Appendix 5.4: Tractor Use, Water Management and the Timing of Cultivation

In Chapter 3.4 we presented labour profiles for owners and non-owners of farm power which indicated that, in irrigated paddy land, the ownership of tractors gave no clear advantage in the timing of cultivation. In this Appendix we support our argument by an analysis of the factors affecting the timing of cultivation in a case study of one location, Padaviya, for the two maha seasons, 1978-79 and 1979-80, the latter falling within our study year. That our case study embraces only one location is of little consequence: our fortnightly supervisory visits to the three study locations (and frequently also to other major irrigation schemes) suggest that the sequence of events at Padaviya is by no means exceptional. The particular advantages of the two seasons' data at Padaviya is that comparisons between them throw the causal factors into sharp relief.

In maha 1978-79 the initial proposal for Padaviya, conforming with the agricultural programme of the Tank Irrigation Modernisation Project,[1] was that land should be tilled and sown on pre-monsoon showers, irrigation water being used only as a supplement to rainfall in the early period of crop growth. Both dry sowing and any mud sowing[2] were to be completed by the Tank Committee's agreed deadline of 15.11.78. Dry sowing, however, was not adopted. The resident Irrigation Engineer attributed this to the delay in harvesting the preceding yala crop, to inadequate rainfall in the period 15.9.78-7.10.78 and to excess rainfall (9.5 inches) in the remainder of October.[3] One could perhaps be forgiven for assuming that farmers might welcome the failure of the dry sowing programme, and, instead, use the heavy rainfall as a starting point for the less risky and preferred practice of mud cultivation.[4] They did not however. The Irrigation Engineer was fully aware of the reasons for their reluctance: "Although there was enough rainfall to commence land preparation for mud sowing by the latter half of October, the colonists would not commence this till they were assured of water issues for mudding", (our emphasis).[5]

His attention therefore turned to the earliest possible provision of irrigation water, consistent with a reasonable degree of confidence that enough water would accumulate eventually to see the season through, so that farmers would not delay land preparation unduly. He was instrumental in arranging a Tank Committee meeting for 29.10.78, at which the farmers' representatives suggested that land preparation should start as soon as the tank level had risen from its current 7'10" to 12'0". The Irrigation Engineer, however, assured them that a 10'0" level would be adequate, implying that he was willing to issue water to permit uninterrupted tilling and planting from that point onwards. By 3.11.78 the 10'0" mark had been topped, and a rapid inflow brought the level to 14'9" by 7.11.78. Two days later - i.e. within a week of the 10'0" threshold having been crossed - water issues started.

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[1] See Part 1 Report, p.135 ff.

[2] Letter of Padaviya Irrigation Engineer to Farm Management Advisor, TIMP, dated 15.12.78.

[3] ibid.

[4] For a discussion of the farmer's subjective perceptions of the two techniques, see Chapter 6 above and Ranatunga et al (1981).

[5] Letter of 15.12.78.

Data provided by the Irrigation Engineer[1] indicated rapid progress thereafter, 90% of planting being complete within 5 weeks of water issues:

	Land Preparation Completed	Sowing Completed
1st week of November	10%	0%
2nd week of November	30%	5%
3rd week of November	60%	20%
4th week of November	80%	50%
1st week of December	90%	80%
2nd week of December	95%	90%

The 1979-80 season provides a remarkable contrast: it commenced in much the same way, with a planting deadline of 15.11.79 set by the initial cultivation meeting, which was subsequently postponed by a Tank Committee meeting held on 27.11.79. Again, the tank was initially slow to fill. From the low level of 6'4½" in the first week of October, 1979, it had reached almost 9'0" by the end of the month, and 17'5" by the end of November.[2] If the Irrigation Engineer had been as sensitive to farmers' requirements as in the previous maha, water issues would again have started in the early part of November, to provide some stimulus to the rapid completion of land preparation. In the event, however, issues did not being until 14.12.79, by which time the tank had reached full capacity of 22'7" and had been spilling for several days.

As the rate of inflow into the tank suggests, rains were heavy in the latter part of October and throughout November. During our repeated visits to the scheme during this period, it was evident that the volume of rain water impounded in paddy fields was more than adequate for mudland tillage. Yet the cultivation of irrigated lands commenced only slowly. Our visual estimate during a visit on 17-18.12.79 suggested that on approximately 40% of the land in the upper reaches, and on over 60% in the lower reaches of the Lower Main Channel tilling had started. By our following visit on 2.1.80, some two-thirds of land had been planted at the the tail end, but less than half at the top ends.[3] Planting was completed just after the middle of the month.

In both years, land preparation and planting were completed within a short time period (4-5 weeks) once the generally agreed starting point had been reached. The availability of tractors made no difference either to the starting point or to the extent of staggering: new 4-wheel and 2-wheel tractors made available under the TIMP were not available for the bulk of land preparation in 1978-79, but were fully commissioned by 1979-80 - and it was the latter season in which the delay was greater.

The only major difference between the two seasons lay in the quality of perception by irrigation officials of farmers' requirements and motivations, and in the appropriateness of the official response. It may come as no surprise to learn that the post of the key administrator (i.e. the Irrigation Engineer) was held by different incumbents in the two years. In 1978-79 the resident I.E. was an officer of wide experience with

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[1] Letter of 15.12.78.

[2] Data supplied by Irrigation Office, Padaviya.

[3] This time-lead of tail over top ends has already been suggested in a different context in Chapter 3.4.

specific field knowledge of the Padaviya irrigation system, and a familiar figure among the farming community. Whilst his detailed knowledge could be attributed in part to repeated field visits during his long tour of duty at Padaviya, deeper qualities of motivation and concern - the recognition that irrigation is a means to an end and not an end in itself, the desire to understand farmers' problems, motives and aspirations, the prompt manipulation of those resources under his administrative purview to assist agricultural production, and above all, the generation of a climate of confidence and mutual respect between irrigation administrator and farmer - are not to be disregarded.

After the departure of this Irrigation Engineer in 1979, his successor remained in post for only a few months to be followed, just prior to the 1979-80 maha, by a relatively inexperienced officer. The combination of unfamiliarity with the locations, inexperience, junior years and rare informal meetings with farmers did nothing to consolidate the atmosphere of confidence and mutual respect carefully built up by the earlier incumbent. Farmers were more concerned than previously to see water flowing from the sluice before they would cultivate in earnest, and the unaccountable delay in issuing water in 1979-80 with its continued issue into May, 1980, long after the bulk of the crop had been harvested, were the main reasons for the non-availability of water for a yala cultivation in 1980. By contrast, some 4,000 acres of paddy were cultivated in yala 1979, with a gross value of some Rs.10m. at prices then prevailing. This provides some measure of production loss in yala 1980.

Further evidence of the pre-eminent importance of a single but complex factor - farmers' confidence in the adequacy and regularity of irrigation water supplies - in determining the timing of cultivation is provided by the contrast between the cultivation calendar on irrigated and on rainfed land. The abundance of early season rains encouraged several farmers to plant paddy as a rainfed crop on non-irrigable lands both within the outside the scheme boundaries. With short season varieties planted in October, much of the harvesting was complete by the end of January, just as the last of the irrigated crop had been planted. Finally, nowhere in our analysis does the access to mechanised power impinge on the timing of cultivation of irrigated paddy lands.

As a footnote, it is important to stress the discrepancy between the weight of factual and circumstantial evidence with points to the need for reassurances regarding the availability of irrigation water as a prime factor in the timing of cultivation, and farmers' own views of the reasons for the delay. Whether from some sense of embarrassment at being seen not to have made best use of the abundant rainfall, or through some inclination to stress those factors most directly amenable to change through outside

'Although an unfashionable quality in the current Sri Lankan trend towards farmer representation in decision taking and one which might be regarded by some as unduly risky when corporate decisions are the norm, the scope for energetic leadership offered by the post of Irrigation Engineer is wide: at perhaps the most mundane level, farmers at Padaviya several times mentioned to the authors the IE's habit of stopping his vehicle to speak to groups of farmers by the roadside and encourage them to cultivate promptly. Such qualities provide an unquantifiable but highly significant contribution to the efficient organisation of major irrigation and to agricultural production.

agencies, the interviews we held with farmers in mid-November, 1979, at a time when the fields were amply flooded with rainwater and in an ideal condition for mudland tillage, produced responses which stressed the delayed availability of credit or the shortage of tractors as reasons for late land preparation. Whilst the former may have had some small influence (it did not, however, delay the tillage of non-irrigated paddy), the latter is clearly untenable in view of the increase in tractor populations between the two seasons 1978-79 and 1979-80.

Farmers' reluctance to admit the reasons for their delay, apart from adding weight to the already substantial body of evidence which casts doubt on the appropriateness of single-interview techniques in ascertaining cause-and-effect relationships in complex socio-economic environments, stresses the need for a wise and sensitive approach by the irrigation bureaucracy in its relations with farmers.

Appendix 3.5: Multivariate Analysis of Yields - Explanatory Notes

TABLE A.3.5.1 REGRESSION COEFFICIENTS BY INDEPENDENT VARIABLE ACCOUNTING FOR VARIATIONS IN PER-ACRE YIELDS AND FARM OUTPUT

Dependent Variable		Independent Variables						
		Constant	Acreage	Labour[2]	Fertiliser	Power Type	Water Availability	R^2
i) Per Acre Yields								
Equation Number	Owner Sample							
1	Uda Walawe	25.402	-14.124	-.524*	15.529*	5.747	-	0.947
			(11.773)	(.185)	(4.324)	(11.734)	-	
2.	Kaudulla	61.511	-9.294	-.124	1.241	3.604	-	0.644
			(4.444)	(.092)	(1.839)	(13.452)		
3	Padaviya	32.356	6.057	-.046	1.030	12.361*	-	0.102
			(7.772)	(.126)	(2.352)	(5.539)		
	Non-Owner Sample							
4	Uda Walawe	51.529	-18.703*	.111	-5.074*	ni	30.941*	0.271
			(5.505)	(.091)	(1.393)		(6.093)	
5	Kaudulla	47.295	3.403	.040	2.305	-8.404	7.535	0.142
			(2.582)	(.044)	(1.453)	(6.999)	(4.149)	
6	Padaviya	72.359	-11.553*	-.022	3.095	-12.456	21.511*	0.286
			(4.974)	(.079)	(2.628)	(7.994)	(9.574)	
ii) Farm Output								
	Owner Sample							
7	Uda Walawe	84.795	16.830*	-.1...	-2.493	19.744*	-.1	0.373
			(5.071)	(.156)	(2.114)	(8.468)		
8	Kaudulla	-3.775	41.813*	.4...*	5.123*	ni	-	0.680
			(12.760)	(.2...)	(2.547)			
9	Padaviya	-93.252	51.302*	-.052	2.678	50.120*	-	0.482
			(23.732)	(.4...)	(2.575)	(15.922)		
	Non-Owner Sample							
10	Uda Walawe	3.241	19.4...*	...5*	-2.583	7.73...	41.536*	0.669
			(5.5...)	(.1...)	(1.666)	(7.203)	(12.138)	
11	Kaudulla	-12.1...	51.765*	0.03...	4.040*	-23.511	2.354	0.760
			(5.257)	(.091)	(1.790)	(12.841)	(7.692)	
12	Padaviya	36.264	21.536*	.041*	1.366	-29.297	54.263	0.505
			(8.9...)	(.1...)	(2.0...)	(16.612)	(20.257)	

Notes:

1. The following units of measurement were used: yield = bushels; labour = man hours (for non-owners) or man days (for owners); fertiliser = hundredweight; power type = 0 (for animal draught) or 1 (for tractors); water availability = 0 (poor) or 1 (good).

2. Specification of the labour variable included only those labout inputs likely a priori to influence output. Three alternative specifications were tried: the first (presented here) involved the aggregation of all labour inputs prior to harvesting; the second involved essentially the same aggregation, but with weighting land preparation labour by 1.5 to allow for the increased productivity of labour attributable to mechanisation; the third aggregated only those labour inputs on planting and crop care. Little difference in the overall results was attributable to these alternative methodologies, although slight increases in the degree of significance of (especially) the farm power coefficient did occur in equations 11 and 12 when the second specification was tried.

3. A star indicates significantly different from zero at the 5% level.

4. ni indicates that the step-wise multiple regression package used (SPSS) prevented inclusion of the variable in question since the marginal increase in explanatory power would have been negligible.

Appendix 3.6: Field Experiments with 4wt and 2wt in Sri Lanka

Officially-sponsored investigations into the tillage performance of 4wt and 2wt were conducted at the main Dry Zone Agricultural Research Station at Maha Illuppallama following the inauguration of the Farm Machinery Designs and Testing Unit (later called the Farm Machinery Research Centre) in June, 1968. The results of trials in 1968 and 1969 are reported by de Alwis, Sathasavampillai and Wickramanayake (1970). Various techniques of tillage were tested on paddy fields under dry and inundated conditions in the B Division of the Research Station. Tractors were driven by representatives of the import agents. The parameters measured included: soil moisture, bulk density, resistance to penetration, weed density, the width and depth of work, time lost in turning, fuel consumption and wheel slip.

Unfortunately, the results are aggregated across wet and dry conditions, and no yield data are given. Nor are data presented on another factor potentially influencing yields, namely weed growth. In spite of this, some interesting inferences can be drawn: where sinkage of a test rig (a rectangular 1" by 3" plate at 50 lbs pressure) exceeded 3" into wet soil, one model of 4wt could not obtain sufficient traction to operate, whereas even a 5" sinkage did not prevent satisfactory operation of a 2wt. Data on wheel slip lend support to this finding: 4wt operated with ploughs or tine tillers (the latter being in almost universal use by smallholders) suffered 24%-37% travel reduction through wheel slip, whereas the forward-thrusting action of rotavators mounted on 2wt (which, again, are almost universal in smallholder farming) or on 4wt gave increased travel over what would have been achieved by running completely without implements.

The time lost in turning was approximately twice as high with 4wt as with 2wt, at some 30% of aggregate running time, though the lack of data on plot size make these data difficult to interpret. The depth of cultivation with 4wt and tine tillers, at 3.0 inches, was substantially below that of 2wt or 4wt with rotavators (4.5"-5.5"); soil inversion efficiency, at 80% for tine tillers, was lower than that for rotavators on 2wt (95-98%) and clod size larger (2.9-3.0" in diameter at mean weight, against 0.5-1.2" for 2wt with rotavators).

From the data presented, it is difficult to draw firm conclusions regarding the likely impact of alternative tillage methods on yields. Certainly, the shallower tillage, poorer inversion and larger clods attributable to 4wt are more likely a priori to have negative than positive effects on yields. Under traditional mudland tillage systems, however, any negative effect may be neutralised by a higher input in subsequent ploughing or levelling operations: the effect of 4wt with tine tillers may therefore be to increase input costs and not necessarily to reduce yields. With ploughing under dry or semi-wet conditions, where inundation cannot assist in soil pulverisation, levelling or in the decomposition of weeds (or in inhibiting their future emergence), the poor tilth associated with 4wt and tine tillers is likely to have more severe effects in additional input (e.g. herbicide) requirements or in negative yield effects.

APPENDIX 4: MECHANISATION AND LABOUR - SUPPLEMENTARY MATERIAL

Appendix 4.1: Labour Inputs for Mechanised Operations

TABLE A.4.1.1: NON-OWNER SAMPLE: Per-acre labour inputs for those crop operations subject to some mechanisation. (Mean over Maha and Yala seasons).

	UDA WALAWE			KAUDULLA			PADAVIYA			ALL LOCATIONS		
ALL LABOUR	Man-hours / Acre Mean	S.E.	No. of Cases	Man-hours/ Acre Mean	S.E.	No. of Cases	Man-hours/ Acre Mean	S.E.	No. of Cases	Man-hours/ Acre Mean	S.E.	No. of Cases
TILLING												
by hand	380.4	53.3	14	224.9	22.0	4	73.1	20.8	4	296.2	42.8	22
by 4wt	498.3	0.0	1	126.3	100.4	3	74.0	12.0	14	106.3	28.7	18
by 2wt	119.2	7.4	40	82.3	9.1	14	58.4	18.3	5	109.3	6.3	59
by animal[2]	175.9	18.6	43	-	-	-	187.9	30.0	12	178.5	17.7	55
by animal	-	-	-	144.4	8.8	126	158.8	19.0	15	145.9	10.8	141
by animal							132.4	19.6	20	132.4	19.6	20
by animal[3] + 4wt							138.7	20.0	17	138.7	17.1	17
LEVELLING												
by hand	36.2	6.7	22	41.9	10.7	11	20.1	5.2	8	34.6	4.8	41
by 4wt	-	-	0	15.1	0.0	1	-	-	0	15.1	0.0	1
by 2wt	3.4	0.3	36	8.1	3.0	6	4.7	0.0	1	4.1	0.5	43
by animal	30.0	0.0	1	24.9	1.8	130	19.6	1.7	66	23.2	1.3	197
THRESHING[4]												
by hand	132.5	28.6	16	25.9	17.2	2	-	-	0	120.6	26.7	18
by 4wt	35.8	2.0	86	37.7	2.3	87	34.4	3.9	64	36.1	1.5	237
by animal	27.0	0.0	1	58.7	3.9	68	39.9	4.7	31	52.5	3.2	100
WINNOWING												
by hand	25.1	4.7	12	22.4	1.5	107	19.5	1.5	87	21.3	1.0	206
by 4wt	-	-	0	30.6	0.0	1	19.4	3.4	7	20.8	3.3	8
by 2wt	16.7	1.6	70	14.2	2.1	31	11.3	0.0	1	15.8	1.2	102
by machine[5]	-	-	0	18.5	1.1	7	-	-	0	18.5	1.1	7
HIRED LABOUR ONLY			Hired as % of all Labour			Hired as % of all Labour			Hired as % of all Labour			Hired as % of all Labour
TILLING												
by hand	79.4	23.8	20.9	48.0	30.8	21.3	36.1	15.5	49.4	65.8	16.4	22.2
by 4wt	413.6	0.0	83.0	24.6	14.1	19.5	47.9	7.6	64.7	63.9	21.6	60.1
by 2wt	65.0	5.1	54.5	47.2	8.1	57.4	42.6	16.2	72.9	58.9	4.2	53.9
by animal	88.5	5.9	50.3	-	-	-	123.1	38.2	63.5	96.0	10.7	53.8
by animal	-	-	-	29.2	4.3	20.2	53.2	9.8	33.5	32.0	3.4	21.9
by animal							58.6	19.4	44.3	58.6	19.4	44.3
by animal + 4wt							69.2	11.9	49.9	69.2	10.0	49.9
LEVELLING												
by hand	10.2	2.7	28.2	2.5	1.7	6.0	7.4	3.2	36.8	7.6	1.7	22.0
by 4wt	-	-	-	2.2	0.0	14.6	-	-	-	2.2	0.0	14.6
by 2wt	3.2	0.3	94.1	1.8	1.3	22.2	4.7	0.0	100.0	3.1	0.3	75.6
by animal	0.0	0.0	0	4.7	1.0	10.9	10.8	1.6	55.1	6.7	0.9	28.9
THRESHING												
by hand	64.4	18.2	48.6	0.0	0.0	0.0	-	-	-	57.2	16.9	47.4
by 4wt	25.9	1.8	72.3	23.1	1.7	61.3	18.9	2.6	54.9	23.0	1.2	63.7
by animal	22.0	0.0	81.5	22.1	3.0	37.6	19.4	3.5	46.1	21.0	2.3	40.0
WINNOWING												
by hand	15.9	3.9	63.3	6.5	1.0	29.0	6.1	0.9	31.3	6.9	0.7	32.4
by 4wt	-	-	-	30.6	0.0	100.0	10.3	1.5	53.1	12.9	2.8	62.0
by 2wt	12.7	1.2	76.0	6.4	1.4	45.1	9.1	0.0	80.5	10.8	0.9	68.4
by machine	-	-	-	10.3	1.1	55.7	-	-	-	10.3	1.1	55.7

NOTES:

1. The farm power sub-categories for each operation refer to those plots on which only the type of power in question was used. Several cases were encountered in which different types of power were used on the same operation; these were excluded from the analysis. This restriction does not apply to the case of human labour, which complemented any other type of power in all operations. The 'by hand' category refers to those cases where human labour alone was employed.
2. 3 categories of animal-powered cultivation are defined. The first refers to the practice of trampling or 'mudding' the pre-wetted soil without implements; the second to the use of animal-drawn ploughs in tilling, and the third to a combination of the first two.
3. A common practice at Padaviya comprised an initial ploughing by 4wt, followed by animal 'mudding'.
4. Threshing by human power involved rubbing the heads of grain on the ground under the human foot.
5. A hand- or foot-operated winnowing fan.

TABLE A.4.1.2:

OWNER SAMPLE: Per-acre labour inputs for those crop operations subject to a degree of mechanisation.[1] (Mean over Maha and Yala seasons)

	UDA WALAWE			KAUDULLA			PADAVIYA			ALL LOCATIONS		
ALL LABOUR	Man-days/ Acre Mean	S.E.	No. of Cases	Man-days/ Acre Mean	S.E.	No. of Cases	Man-days/ Acre Mean	S.E.	No. of Cases	Man-days/ Acre Mean	S.E.	No. of Cases
TILLING												
by hand	-	-	0	-	-	0	13.3	0.0	1	13.3	0.0	1
by 4wt	-	-	0	5.5	1.5	2	6.9	0.9	22	6.8	0.9	24
by 2wt	6.9	1.1	17	12.7	1.6	10	8.1	0.8	19	8.4	0.6	46[7]
by animal[2,6]	14.1	2.5	18	13.1	0.7	45	15.9	2.4	18	13.9	0.9	63[7]
LEVELLING												
by hand	3.1	0.8	6	1.0	0.0	1	7.2	1.8	3	4.1	1.0	10
by 4wt	-	-	0	2.0	0.0	1	0.4	0.1	13	0.5	0.1	14
by 2wt	0.6	0.1	9	2.0	0.4	12	1.3	0.2	6	1.4	0.2	27
by animal	-	-	0	3.9	0.5	50	3.2	0.5	29	3.7	0.4	79
THRESHING												
by hand	-	-	0	-	-	0	-	-	0	-	-	0
by 4wt	1.9	0.3	35	7.2	0.5	57	3.5	0.4	57	4.5	0.3	149
by animal	-	-	0	6.4	1.5	15	7.0	1.1	16	6.7	0.9	31
WINNOWING												
by hand	2.5	0.4	10	4.4	0.5	25	3.3	0.4	27	3.7	0.3	62
by 4wt	0.4	0.0	1	-	-	0	1.4	0.2	27	1.3	0.2	28
by 2wt	1.1	0.4	21	4.1	0.5	37	2.2	0.5	21	2.8	0.3	79
by machine[5]	-	-	0	0.6	0.3	6	-	-	0	0.6	0.3	6

HIRED LABOUR ONLY			Hired as % of all Labour			Hired as % of all Labour			Hired as % of all Labour			Hired as % of all Labour
TILLING												
by hand	-	-	-	-	-	-	10.7	0.0	80.5	10.7	0.0	80.4
by 4wt	-	-	-	3.4	0.1	61.8	6.5	0.9	94.2	6.2	0.9	91.2
by 2wt	5.3	1.0	76.8	8.7	1.8	68.5	5.4	0.7	66.7	6.1	0.6	72.6
by animal	13.1	2.4	92.9	6.5	0.5	49.6	3.5	0.6	22.0	5.7	0.4	41.0
LEVELLING												
by hand	2.2	1.1	71.0	0.0	0.0	0.0	2.4	1.2	33.3	2.1	0.8	51.2
by 4wt	-	-	-	0.0	0.0	0.0	0.3	0.1	75.0	0.3	0.1	60.0
by 2wt	0.4	0.1	66.7	1.3	0.4	65.0	1.1	0.3	84.6	0.9	0.2	64.3
by animal	-	-	-	1.9	0.3	48.7	1.7	0.4	53.1	1.8	0.2	48.6
THRESHING												
by hand	-	-	-	-	-	-	-	-	-	-	-	-
by 4wt	1.6	0.3	84.2	5.5	0.4	76.4	2.9	0.3	82.8	3.6	0.3	80.0
by animal	-	-	-	3.6	1.2	56.3	4.5	0.9	64.3	4.1	0.7	61.2
WINNOWING												
by hand	1.9	0.6	76.0	2.0	0.4	45.5	1.7	0.3	52.0	1.8	0.2	48.6
by 4wt	0.4	0.0	100.0	-	-	-	1.2	0.2	85.7	1.1	0.2	84.6
by 2wt	0.8	0.4	72.7	2.5	0.3	61.0	1.6	0.5	72.7	1.9	0.2	67.9
by machine	-	-	-	0.5	0.2	83.3	-	-	-	0.5	0.2	83.3

NOTES 1-5 correspond with those given below Table A.4.1.1.

6. Refers to trampling the pre-wetted soil (mudding) at Uda Walawe, and the use of animal-drawn ploughs elsewhere.

7. In view of the disparity described in Note 1, the "all areas" figure includes only Padaviya and Kaudulla.

Appendix 4.2: Mechanisms of Labour Displacement

An important finding in the discussion of the labour displacement effects of mechanisation in Chapter 4 was that withdrawal of family labour was generally more significant than the displacement of hired labour.

Fieldson (1981) advances two main reasons for the much greater decline in family than in hired labour use. Their consideration is, however, complex, relying on analysis of observed labour use patterns, not of the hypothetical technology levels discussed earlier. Fieldson's arguments can be summarised as:

(i) Reduced opportunities for family labour use

The change in technology from animal to mechanised systems may reduce the opportunity for family labour use, particularly in the case of those relying on hiring in. When draught animals are hired, part of the labour necessary for driving them is conventionally supplied by the hirer. If we assume that, for the 150 buffalo pair hours needed to prepare and thresh one acre, a total of 60 driver hours is needed,[1] then 30 hours per acre will commonly be supplied from the hirer's family. With the change to mechanised systems, the driving is performed entirely by the tractor owner, so that this role for hirer's family labour is immediately removed. There is some evidence[2] that the amount of manual work necessary for repairing bunds and for tilling into the corners of liyaddes is higher with tractor than with buffalo ploughing, which may potentially compensate for some of the loss of opportunity for family labour in driving the power source, but the scope for family labour to change its function in this way is limited by the timing requirements of mechanised operations. With threshing, for instance, the standard paddy allotment of some 3 acres can be threshed in less than one day's work by tractor, whereas the same 3 acres would take 3 pairs[3] of buffalo approximately 4 days[4] to complete. If, as seems likely, the total amount of labour required (other than for driving) differs little between tractor and buffalo threshing, the more 'peaked' requirements of tractor threshing will necessarily involve a higher proportion of hired labour in the total input.

Whilst the family labour work opportunity lost through the mechanisation of land preparation and threshing is substantial - amounting to some 30 hours per acre for driving the power source in both operations, plus some additional 20 hours per acre[5] lost through the increased 'peakiness' of threshing labour requirements, substantial amounts of hired labour over and above the driving requirement continue to be employed in, particularly, mechanised land preparation. The possibility, therefore, exists for family labour - if its displacement from the work it normally performed in animal powered tillage were involuntary - to substitute for hired labour in the work peripheral to mechanised ploughing (e.g. repairing bunds, finishing off the corners and edges of liyaddes). That it has not done

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[1] One driver is adequate for several pairs of buffalo in certain operations (e.g. threshing and 'mudding'), so that the total driver requirements will be a fraction of the buffalo pair time. Work performance rates for this section are taken from Table 3.2.1.

[2] Carr, 1975, p.280 ff.

[3] The number of buffalo pairs employed in threshing a single stack of paddy may be fewer or greater, but 3 pairs are commonly use.

[4] e.g. for heaping the stack, removing straw, clearing the threshing floor.

[5] Data from Appendix 4.1.

so suggests that non-owners have voluntarily allowed[1] tractors to substitute for their family labour, which they have then allocated to various alternative economic or non-economic uses. Potential alternative employment opportunities constitute the remaining reasons advanced by Fieldson for reduced family labour inputs. These are now examined in turn.

(ii) The allocation of family labour into alternative uses

(a) Alternative family enterprises

Displaced family labour may be used in the production of crops other than paddy. As we have seen, however,[2] the acreage of non-paddy crops successfully cultivated by owners was low (maha 5.40 acres; yala 8.25 acres) and absolutely and relatively much lower than that of non-owners. Further, where non-owners cultivated non-paddy crops they did so because of uncertain irrigation supplies, not because mechanisation released the necessary family labour. There thus seems little to support the possibility of such a diversification of effort, a finding adumbrated in earlier work by Carr (1975).

(b) Alternative non-farming enterprises

Substantial evidence of a diversification by tractor owners into non-farming enterprises exists. This absorbs substantial amounts of their labour, and generates hired labour employment opportunities. It is the subject of more detailed discussion in Chapter 4.2. For non-owners, however, this is not the case.

(c) Indirectly productive or non-productive activities

There is evidence that much of the reduction in family labour use with increasing levels of mechanisation is attributable to a withdrawal of female and child labour into indirectly productive or non-productive activities (especially housework and education). Data aggregated across all locations, for instance, indicate that female and child labour accounted for 9.0% of the total family labour input into agricultural operations for 4wt owners, but 26.5% for 2wt owners, 25.6% for buffalo owners, and 23.7% for non-owners.[3] The impact of this withdrawal of female and child labour by 4wt owners is substantial - it accounts for almost 40% of the difference in observed family labour inputs between buffalo and 4wt owners (Table 4.1.1).

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[1] Chapter 3.4.

[2] Significant differences between locations were not observed.

[3] The slightly lower figure for non-owners than for 2wt or buffalo owners may conceal some withdrawal of female and child labour by those non-owners who hired tractors. Time constraints prevented separate analysis of the female and child labour inputs for non-owners by type of power hired.

Appendix 4.3: The Role of Seasonally Migrant Labour at the Study Locations

The proportion of total hired labour input attributable to seasonally migrant labour may be expected to vary according to such factors as local man: land ratios, and distance from the Wet Zone areas of high population density in which migratory movements originate. An assessment of the extent and patterns of its incidence throughout the Dry Zone would therefore require a large sample of farms, stratified by:

- distance from the Wet Zone,
- population density in relation to agricultural land,
- the density of opportunities for casual employment.

Neither the main existing studies on rural labour (Crooks and Ranbanda, Perera and Gunawardena, op. cit.) are based on such a sampling scheme; nor is our own. The current state of knowledge concerning the scale and spatial patterns of seasonal migration therefore remains weak. Our own study, however, gives some indication of its scope at the three study locations:

TABLE A.4.3.1: FREQUENCY DISTRIBUTION OF EMPLOYMENT OF SEASONALLY MIGRANT LABOUR IN MAHA 1979-80 BY LOCATION AND OWNERSHIP STATUS

Seasonally migrant as % of all hired labour:		0%	25%	50%	75%	100%	All
	No. employing:						
UDA WALAWE:	Owner Sample	41	5	1	2	0	49
	Non-owner Sample	52	3	1	1	1	58
KAUDULLA:	Owner Sample	7	7	4	32	7	57
	Non-owner Sample	28	2	4	7	12	53
PADAVIYA:	Owner Sample	54	8	1	2	0	65
	Non-owner Sample	49	18	2	0	0	69
ALL LOCATIONS:	Owner Sample	102	20	6	36	7	171
	Non-owner Sample	129	23	7	8	13	180

Source: Data extracted from responses in Sociology Schedules.

At both Uda Walawe and Padaviya, heavy reliance on migrant labour (i.e. 75-100% of all hired labour) was extremely rare - under 5% of respondents at each location. At Kaudulla, by contrast, 68% of the owner sample and 36% of non-owners relied on migrants for 75% or more of their hired labour requirements.

This pattern to a large extent follows the arguments developed above: Padaviya, some 150 miles distant from the main Wet Zone areas (e.g. Kegalle District, c f. Crooks and Ranbanda, op. cit.) in which migrations originate, has little chance of attracting large volumes of labour over such distances when areas such as Kaudulla lie at little over half the distance away from the Wet Zone, and, situated in a paddy complex of some 60,000 acres, offer abundant employment opportunities. At Uda Walawe, an area in which local population density is high relative to total paddy acreage, and paddy farms relatively small (c f. Tables 3.4.1-3.4.2) the capacity of farm families and local hired labour to cope with the necessary work is high, with a correspondingly reduced requirement for migrant labour.

Interestingly, at Kaudulla, the reliance on high proportions of migrant labour is almost twice as heavy among owners as among non-owners. This can be accounted for both by the fact that their operated irrigated holdings are twice the size of those operated by non-owners, and by their higher incomes (Chapter 5), which facilitate both cash payments to large gangs of labour and the arrangement of transport and accommodation for them.

APPENDIX 5 : INCOMES AND WEALTH AMONG OWNERS AND NON-OWNERS

The data that were collected regarding financial transactions fall into two main groups, viz. incomings and outgoings, identical data schedules being used to collect data from owner and non-owner samples. From non-owners data were collected on a fortnightly basis and from owners, on a monthly basis. For reasons discussed in the Part 1 Report (Chapter 2.4), only a subset of the owner sample was selected for collection of these data.

As outlined in the same discussion of methodologies the non-owner sample was stratified within the scheme depending on the distance between farm holdings and the irrigation head works. The owners were classified according to power type: when an owner had two different types of power, he was classified under the grouping appropriate to his power type with the highest horsepower. A very small number of owners having more than one tractor of the same type were excluded from the analysis to avoid computational difficulties.

Details of the Survey Schedules and Methodology are given elsewhere (Part 1 Report, Chapter 2.4 and Appendix IX). Since the intention was to investigate transactions in the agricultural and not the domestic economy, day to day expenditure on minor household items (including food) was not recorded. Nor was any allowance made for the consumption of own-produced food. If we accept the commonly held view that the diet of richer households, as constituted both by purchased and home-produced food, will be qualitatively and quantitatively superior to that of the poorer, then the effect of these simplifications will be in opposite directions: whilst the former will underestimate expenditure (and, therefore, overstate net incomes) more severely for the rich than for the poor, the latter will underestimate net incomes of the rich relatively more severely. The biases will therefore be self-cancelling to some extent.

Within each of the broad owner/non-owner categories the following sub classifications are used:-

a) by location,
b) between groups within location and between groups across locations,
c) by source of earnings and expenditure.

Finally, it should be borne in mind that our samples were drawn from purposely selected sub-populations within each location. In a sample statistical sense, they are therefore not strictly representative of the locations as a whole. Our repeated visual observations and much circumstantial evidence nonetheless confirm that the broad orders of magnitude are correct.

Appendix 5.1: Income and Expenditure Patterns - Non-owner Sample

1. Income

The average annual gross earning between the three locations under study show that although the mean value for all schemes is Rs.4,928.55, Kaudulla appears to have a better earning capacity than the other two locations, (Kaudulla Rs.6,001.85 p.a., Uda Walawe Rs.4,356.80 p.a. and Padaviya Rs.4,428.00 p.a.) The earnings by all groups in Kaudulla were

significantly different from the other two locations (P=0.10), but there was no significant difference between the earnings of Padaviya and Uda Walawe. Earnings from the sale of agricultural produce constitute the largest portion in all the three locations ranging from 64% in Padaviya, to 74% in Kaudulla and 87% in Uda Walawe. The Padaviya sample had to rely heavily on off-farm earnings (27%) in view of the absence of yala cropping (see Table A.5.1.1).

Closer investigation of the reasons for inter-location variability in earnings requires disaggregation of the non-owner samples into groups designed to reflect their access to a key production input: irrigation water (see Table A.5.1.1.). The Standard Error figures in all income/expenditure tables are based on values per 14 months. For easy reference annual mean values are given.

a. Uda Walawe

The incomes of the non-owners show a rapid decline towards the tail end of the scheme. For example the average annual cash earnings of a farmer in Tract 19 (Group 4) are only about 15% of that of a farmer in Tract 4 top end (Group 1). This decline in incomes is mainly due to the low availability of irrigation water for cultivation. This is substantiated by the fact that the proportion of incomes from the sale of agricultural produce also declined from Group 1 to Group 4. In Group 1 the proportion is about 88% while in Group 4 it is only about 60%. Although there is a slight decrease in Group 2 (Tract 4 bottom end) the difference between Group 1 and 2 is not significant (P=0.01). Two further interesting facts arise from this analysis. On the one hand the proportion of earnings from off-farm activities increases rapidly from 6.1% in Group 1 to 36.3% in Group 4 (except for a decline in Group 2 (from the Group 1 level) which was again not significant (P=0.01) and on the other hand, although the proportion was less than 2% of the total annual income, there has been some selling of household items of individual value exceeding Rs.20.00 by the farmers in the bottom two groups, to augment their earnings. These findings provide further evidence of the inadequate livelihood-generating capacity of agriculture at the tail end.

b. Kaudulla

The same general pattern prevailed in Kaudulla too. However, what is more important is that especially Group 2 which is at the bottom end of Tract 1 shows lower income figures than Group 1, although these figures are not statistically significant, this is an indication of the water problems that are faced by the tail enders of Tract 1. The fields at the bottom end of Tract 1 are located on heavy soils with minimal slopes, so that they tend to be badly drained. Periods of water shortage attributable to long distances from the head works and the poor condition of canals thus alternate with the flooding which results from poor drainage after heavy rain. In statistical terms, the differences between the incomes in the first three groups were not significant. The incomes of Group 4 (off scheme group) was significantly different from that of Group 3 (Tract 8) at P=0.10. Although there was a decline in the earnings of the Group 4 non-owners, which were a little over half the earnings of the Group 1, this remained much higher than the Uda Walawe Group 4 non-owners. Although the Group 4 non-owners in Kaudulla were located outside the irrigation scheme they were better off than the Uda Walawe tail end non-owners.

Non-Owner sample

TABLE A.5.1.1: AVERAGE ANNUAL REVENUE PER FARMER CLASSIFIED BY SOURCE OF EARNINGS AND GROUPS*

I D	GROUP 1 Mean p.a.	No.	S.E.	GROUP22 Mean p.a.	No.	S.E.	GROUP 3 Mean p.a.	No.	S.E.	GROUP 4 Mean p.a.	No.	S.E.	ALL GROUPS Mean p.a.	No.	S.E.
Scheme: UDA WALAWE															
Off farm earnings	479.60	20	224.9	234.80	20	93.8	302.40	20	209.1	414.00	20	127.7	357.40	80	85.7
Hiring of machinery	294.60	20	343.8	88.90	20	99.6	-	20	-	0	20	-	95.90	80	89.2
Sale of crop and livestock	6762.00	20	702.5	6330.00	20	694.2	1314.80	20	268.4	678.00	20	224.7	3771.40	80	447.2
Incomes from pensions etc.	225.00	20	125.2	109.70	20	88.1	120.40	20	53.0	30.00	20	19.6	121.20	80	41.0
Sale of machinery	-		-	-		-	-	20	-	-		-	-	80	-
Sale of household items	-		-	-		-	26.40	20	23.5	17.14	20	20.0	10.80	80	7.7
Mean for each group	7760.70	20	876.7	6763.40	20	665.7	1764.00	20	333.5	1139.10	20	259.1	4356.80	80	481.7
Scheme: KAUDULLA															
Off farm earnings	1035.40	19	429.3	1684.20	19	408.3	685.71	19	239.4	831.40	20	324.5	1056.00	77	182.5
Hiring of machinery	103.80	19	88.4	-	19	-	60.94	19	71.0	47.10	-	45.5	52.88	77	30.1
Sale of crop and livestock	5581.70	19	101.6	7581.40	19	4478.0	4867.71	19	849.0	3015.40	20	697.0	5232.85	77	1164.0
Incomes from pensions	846.60	19	272.8	697.60	19	176.5	156.34	19	182.4	33.20	20	16.5	428.31	77	101.4
Sale of machinery	-		-	-		-	15.78	19	18.4*	-		-	3.90		4.5
Sale of household items	18.00	19	21.05	18.90	19	15.87	80.07	19	45.6	-		-	28.88		13.3
Mean for each group	7585.50	19	1045.0	9982.10	19	4551.0	4551.00	19	908.0	3927.00	20	498.0	6802.78	77	1202.0
Scheme: PADAVIYA															
Off farm earnings	1103.10	20	246.4	1264.20	20	428.0	776.50	20	130.0	1764.80	20	328.3	1227.40	80	156.1
Hiring of machinery	833.90	20	492.6	221.40	20	103.3	6.60	20	4.4	-			265.40	80	131.2
Sale of crop and livestock	2383.70	20	483.3	3202.20	20	599.9	4829.10	20	815.8	928.80	20	310.3	2836.20	80	340.2
Incomes from pensions	34.20	20	28.4	113.50	20	66.7	30.00	20	24.3				44.40	80	19.5
Sale of machinery	2.10	20	2.5	39.60	20	27.7	21.40	20	25.0				15.80	80	9.4
Sale of household items	61.50	20	39.5	39.80	20	26.3	55.70	20	65.0				39.20	80	19.9
Mean for each group	4418.50	20	947.7	4880.70	20	790.0	5719.30	20	889.5	2693.60	20		4428.40	80	410.0
ALL SCHEMES	6588.20			7208.50			4011.40			2586.40			5195.99		

S.E. = Standard Error; these figures are based on revenue per 14 month basis.
No. = Number of observations.

The groups are defined as follows: Scheme	Group 1	Group 2	Group 3	Group 4
Uda Walawe	Tract 4 top end	Tract 4 bottom end	Tract 18	Tract 19
Kaudulla	Tract 1 top end	Tract 1 bottom end	Tract 8	Off Scheme
Padaviya	Tract 2	Tract 6 top end	Tract 6 bottom end	Tract 12

This may be due to the fact that the Kaudulla off scheme non-owners were more assured of water supply for cultivation, on the one hand being fed by village tanks and, on the other, by drainage water from Kaudulla irrigation scheme. Again the two major components of earnings in each group were the sales of agricultural produce and off farm activities. Although there is some indication that water shortages occur down the scheme and along distributaries, the earnings figures do not explicitly show this. The decrease in earnings from agricultural produce sales from Group 1 to 3 are not significant (P=0.05). However, the decrease in off scheme earnings from sales of agricultural produce was significant by comparison with all other groups (P=0.01). This gives us some indication that within stage 1 of Kaudulla scheme problems with access to water were not acute.

One reason for the higher average income in Group 2 is that the proportion of off farm earnings is much higher than for Group 1 or 3. In the off scheme group (Group 4), the proportion of off farm earnings (21%) is higher than for the other three groups lying within the irrigation scheme, for much the same reasons as were advanced above in the discussion of the tail end groups at Uda Walawe.

c. Padaviya

Although there is a significant decline in income in Group 4 (Tract 12) from Group 1 (Tract 2) (Rs.2,693 p.a. and Rs.5,155 p.a. respectively) (P=0.05), the incomes in the other two groups were significantly higher than in Group 1 (P=0.05), where non-owners are generally in a most privileged position as far as water availability is concerned. The two most important components of overall earnings are, again, income from sales of agricultural produce, which is a function of farm size, yields and water availability, and off farm earnings. Although our groupings were based mainly on water availability criteria, and specifically Tract 6 was divided into Groups 2 and 3, since water is not available to the latter during the yala season, these criteria were irrelevant during our survey period, since water supplies were abundant (except for the bottom end tracts) in maha, and no water was issued at all in yala. Thus our stratification became void. The significant increase in incomes from agricultural produce sales in Group 3 over Group 2 (about 5% increase) and over Group 1 is attributable to the higher yields and larger acreages cultivated here (Tables 3.4.2 and 3.5.1). However the tail enders (Group 4 in Tract 12) are again worst affected, since they do not get enough water even for maha cultivation, hence the reduction in income. In other groups, whereas the proportion of agricultural sales income over total incomes was more than 50%, in Tract 12 it was only 34%, and in fact the proportion of off farm earnings was very high (65%). This corresponds with the pattern discussed above for the tail ends of Kaudulla and Uda Walawe.

d. All Locations

When all locations are taken together a pattern similar to that for individual locations again emerges. The last two groups show substantial reductions and the overall cash earnings of the fourth group is only about 40% (Rs.2,586.40) of that of Group 1 (Rs.6,588.20) (see Table A.5.1.1). This substantiates our argument advanced above that inadequate availability of water at the tail ends causes substantial imbalances in income distribution within irrigation schemes, and is a dominant cause of variation in incomes over time.

In attempting to identify reasons other than those discussed above for the intergroup variations in income and expenditure, four possible factors emerge:

i) cropping mix,
ii) cropping intensity,
iii) farm size and composition,
iv) a fourth explanatory variable requires consideration in inter-location comparisons, namely the opportunities for off-farm earnings.

We would go so far as to suggest that it is water availability which has the most fundamental bearing on cropping patterns. Farmers preferences for irrigated paddy are documented in many reports and, in the absence of intense official support, non-paddy crops are grown only where insufficient irrigation water is available (e.g. Farrington, 1979; Wijayaratne, 1981).

This is most strikingly apparent at Uda Walawe (see Table A.5.1.2) where the income from sales of paddy declines from top to tail end whilst the number of crops grown increases. In the two top groups the income from paddy amounts to more than 97% of the agricultural income, whilst in Groups 3 and 4, it was only 28.0% and 2.5% respectively. One striking example is the earnings from cotton on Group 4, which amounts to 44% of the total agricultural earnings in that group.

TABLE A.5.1.2: TYPE OF CROP GROWN AND LIVESTOCK PRODUCTS PRODUCED BY DIFFERENT GROUPS

Scheme	Group 1	Group 2	Group 3	Group 4
Uda Walawe	Paddy, gingelly, other legumes	Paddy, cowpea, gingelly	Paddy, green gram, groundnut, cotton, green chillies, vegetables, milk, red chillies, gingelly	Paddy, green grams, gingelly, chillies vegetables, cotton, permanent crops
Kaudulla	Paddy, chillies, other vegetables	Paddy, cowpea, chillies, poultry, permanent crops.	Paddy, chillies, permanent crops.	Paddy, cattle,
Padaviya	Chillies, paddy, Maize, vegetables, milk, permanent crops	paddy, cowpea, chillies, vegetables, curd, black gram.	Paddy, cattle	Paddy, kurakkan, other vegetables

(i) Cropping Mix.

In Kaudulla, paddy remained the dominant crop in all the groups. Although earnings from paddy were relatively low at the bottom end, the proportion of income from paddy still constituted more than 96% of the total agricultural produce sales. Thus the earnings from non paddy crops remained marginal. A further factor was the adoption of 'bethma' cultivation in yala, 1980, several of the bottom end farmers did not, however, cultivate paddy during the yala season for reasons discussed elsewhere (Chapter 3.4).

At Padaviya too, although paddy is the more dominant crop, the income from paddy was considerably lower in Group 4 in absolute value and as a proportion of agricultural income, which was 79.5% compared to more than

95% in the other groups. Although crop diversification is not seen in Padaviya tail end as in Uda Walawe, a substantial proportion of agricultural income was derived from dry land crops like kurakkan (81%) by the Tract 12 non-owners.

Another important observation was that although incomes from livestock produce were very low, in Padaviya and Uda Walawe, there were some recorded sales of buffalo milk and curd; whereas none were mentioned in Kaudulla. As was cited in the Part 1 Report, the herd size in Uda Walawe and Padaviya is very much larger than in Kaudulla and at Uda Walawe in particular, farmers consider the buffalo as a dual purpose animal (males for field work and the females for milk, though this division is not rigidly adhered to), but in Kaudulla, the herd size is very small, and both males and females are working intensively. Therefore the farmers do not milk the females for sale purposes. Recorded sales of this item are likely, however, to be an underestimate of sales for the entire populations at the study locations, since the intention in selecting the non-owner sample, was to eliminate buffalo owners, although this proved impossible in some case (see Appendix 1).

(ii) Cropping Intensity.

Following on from the full discussion of cropping intensities in Chapter 3.1.4, it is worth re-emphasising here that no irrigation water was available at all for yala cropping at Padaviya; adequate water was available at Kaudulla for only a bethma cultivation on part of the command area during yala, and full supplies were available at Uda Walawe, though the severe water availability problems at the tail ends reduced the level of irrigated cropping in both seasons.

(iii) Farm Size and Composition

As outlined in the preceding paragraphs, income from agriculture takes the major share in non-owners earnings and overall paddy sales and the most important element within agriculture, in spite of variations in income levels for paddy sales within locations. One of the most important variables in paddy production is land under irrigated cultivation which includes owned, encroached and rented in paddy lands. An analysis of land under paddy cultivation is possible at two levels: (a) the mean acreage/season over maha and yala. This method is better for Uda Walawe since irrigation water was available at the same level for both seasons. However, the second method, (b) analysis of mean maha acreage, is more appropriate for Kaudulla and Padaviya, since it was only during maha that all the farmers received irrigation water.

Both methods are used in the analysis below, since (a) is the more appropriate in calculating incomes since it reflects total annual cropped acreage. However, (b) is also important, since especially at Padaviya and Kaudulla farmers' decisions on crop sales may have been influenced by their maha surplus, if they had expected a yala crop. Therefore, the maha average may correlate more closely with sales from average acreage over the two seasons.

This analysis clearly confirms that the land under paddy is closely related to the income from paddy sales. For example in Uda Walawe the land area under paddy for both maha and mean acreage declines from Group 1 to 4 (see Table A.5.1.3) (Groups 3 and 4 have equal size). The decline

in Group 2 is not significant but the decline from Group 2 to Group 3 and 4 is highly significant at P=0.01 for maha and P=0.05 for the mean acreage. The data from Kaudulla was a little confusing. Analysis of the data on a seasonal average basis show a decrease in the Group 2 land size over Group 1 (P=0.05) (corresponding with the drop in paddy sales), but there was no significant difference between Groups 2 and 3. The maha data analysis shows no significant difference between the groups. The result of the seasonal acreage analysis too is not surprising, since during yala, bethma cultivation was practised in the higher reaches of the scheme and the Group 1 non-owners cultivated a larger (significant over Groups 2 and 3 at P=0.05 and P=0.01 respectively) extent than the 1 acre allotted, by renting in the share that was allotted to the bottom end non-owners. The maha analysis falls in line with our earlier proposition that in Kaudulla there is an egalitarian distribution of water and income. In Padaviya too, both maha and seasonal acreage data (there was no yala paddy at all) show that in Group 4, i.e. Tract 12, there is a marked decrease in paddy land acreage over the other groups (P=0.01), there being no significant difference among these. This shows that lack of irrigation facilities at the bottom end has caused the very low paddy cultivation levels.

TABLE A.5.1.3: OPERATED PADDY ACREAGE PER NON-OWNER (OWNED, ENCROACHED AND RENTED IN) BY DIFFERENT GROUPS

Scheme	Season	Group 1			Group 2			Group 3			Group 4		
		Acres	No.	S.E.	Acres	No.	S.E.	Acres	No.	S.E.	Acres	No.	S.E.
Uda Walawe	Maha	2.55	20	0.17	2.10	20	0.12	1.80	20	0.15	1.59	20	0.12
	Seasonal Average	2.19	40	0.17	2.05	40	0.12	1.19	40	0.14	1.19	40	0.12
Kaudulla	Maha	2.50	19	0.35	1.77	19	0.37	2.28	19	0.29	3.30	20	0.36
	Seasonal Average	2.05	38	0.21	1.14	38	0.22	1.22	38	0.23	1.74	20	0.34
Padaviya	Maha	2.76	20	0.24	3.17	20	0.26	2.97	20	0.18	1.20	20	0.17
	Seasonal Average	1.38	40	0.25	1.58	40	0.28	1.50	40	0.25	0.13	40	0.13

No. = No. of observations; S.E. = Standard Error

(iv) Off Farm Earnings

Disaggregating the sources of off farm earnings provides further evidence of the overriding importance of water availability. The most interesting indicator is the proportion of earnings obtained through hiring out of labour for agricultural purposes, since farmers would be unlikely to work on other farms if their own could provide adequate livelihoods and employment. The total earnings from off farm earnings are given in Table A.5.1.1. In Uda Walawe, the proportion of off-farm earnings from labour hire increased for Group 1 (36.0%) to Group 4 (61.4%). However, within Kaudulla scheme this proportion does not vary much (between 22.6% and 29%), which again supports the hypothesis that throughout this scheme, all the non-owners have equal opportunity for their own farming. In Padaviya again the same trend at Uda Walawe emerges. For example in the top 2 groups the proportion is an average of 23%, whereas in Group 4 (Tract 12) it is about 41%.

Another important difference lies in the earnings from 'white collar employment', i.e. teaching, post office officer, co-operative employee and other government employments. In all the schemes it is evident that

earnings obtained from this source are negatively correlated with distance from the irrigation headworks. For example in Uda Walawe and Kaudulla only the Group 1 non-owners had earnings from this source (26% and 8.5% respectively). In Padaviya, though all the groups had a share, in the two top groups it was 21.4% and 45.4% while in the botton two groups the figures were 13.2% and 0.9% respectively. This difference is attributable largely to the proximity of government offices etc. to the headworks (Maps A8.1-2. Furthermore, the top end farmers, by virtue of their better income position appear to have acquired better educational standards for their children compared with the tail enders, so that their families as a whole are better placed to reap the earnings advantage available in white collar employment (see Table A.5.1.4).

TABLE A.5.1.4: MEAN NUMBER OF YEARS OF EDUCATION ATTAINED BY MEMBERS OF NON-OWNER HOUSEHOLDS WITHIN THE 15-65 YEARS AGE GROUP

LOCATION	GROUP 1			GROUP 2			GROUP 3			GROUP 4			ALL NON-OWNERS		
	Mean	No.	S.E.	Mean	No.	S.E.	Mean	No.	S.E.	Mean	No.	S.E.	Mean	No.	S.E.
UDA WALAWE	4.84	20	0.52	3.96	20	0.43	6.64	19	0.51	5.54	17	0.53	5.21	76	0.27
KAUDULLA	6.46	18	0.41	6.21	19	0.48	6.26	16	0.57	4.89	20	0.46	5.92	73	0.24
PADAVIYA	5.79	20	0.48	6.30	20	0.40	4.90	20	0.54	4.48	20	0.59	5.35	80	0.26
ALL LOCATIONS	5.69	-	-	5.48	-	-	5.90	-	-	4.93	-	-	5.49		

Notes: No. = Number of Observations; S.E. = Standard Error.

2. Expenditure

Data on expenditure items included all expenditure on farming operations, i.e. for labour, farm machinery, inputs and repairs to farm machinery, purchase of farm machinery, equipment and livestock, purchase of household items in excess of Rs.20/-, and payment of credit. Day to day expenditure on food, clothing, transport, health and education etc. were not collected. All data were broken down into credit expenditure and expenditure from own funds.

Comparison of non-owners' expenditure with their gross incomes permits analysis of the availability of funds for day to day expenditure on domestic requirements, transport, etc. and capital investments in either the home or the farm. For the purposes of our discussion below, these funds are referred to as 'net revenue'.

The mean expenditure value for all locations Rs.3,476.70, i.e. 70.5% of the gross income. This figure varies from 63.2% in Uda Walawe to 67.3% in Kaudulla and 82.0% in Padaviya (see Table A.5.1.5). These figures show that although Padaviya has an income comparable with Uda Walawe, its expenditure levels are high, and with no yala cropping, the people in this scheme as a whole had to undergo severe difficulties in the second half of 1980. When figures within locations are compared, then income/expenditure patterns give an indication of living standards. In Uda Walawe expenditure as a percentage of income rises from Group 1 to 4. We observed that the gross incomes themselves were very low in the lower 2 groups relative to the upper 2. Low incomes and the minimal amounts remaining for day to day expenditure establish beyond doubt the poverty-stricken condition of the bottom end farmers at Uda Walawe.

TABLE A.5.1.5: AVERAGE ANNUAL INCOME AND EXPENDITURE PER NON-OWNER AND EXPENDITURE AS A PERCENTAGE OF INCOME

Scheme		Group 1 Rs	%	Group 2 Rs	%	Group 3 Rs	%	Group 4 Rs	%	All Groups Rs	%
Uda Walawe	Income	7,760.70		6,763.40		1,764.00		1,139.10		4,356.80	
	Expenditure	4,209.00	54.2	4,642.90	68.6	1,235.31	70.0	905.60	79.5	2,757.00	63.2
Kaudulla	Income	7,585.50		6,734.00		5,866.90		3,927.10		6,000.85	
	Expenditure	4,781.70	65.0	4,722.40	70.1	3,359.40	57.2	3,371.10	85.8	4.039.10	67.3
Padaviya	Income	4,418.50		4,880.70		5,719.30		2,693.60		4,428.00	
	Expenditure	4,291.70	97.1	3,311.70	67.8	5,072.70	88.6	1,865.50	69.2	3,634.00	82.0
All Locations	Income	6,583.30		6,126.03		4,450.00		2,586.60		4,928.95	
	Expenditure	4,427.46	67.2	4,225.66	68.9	3,222.47	72.4	2,047.40	79.1	3,476.70	70.5

Note: Expenditure/income x 100.

TABLE A.5.1.6: MEAN ANNUAL OWN EXPENDITURE PER NON-OWNER AS A PERCENTAGE OF TOTAL EXPENDITURE

Scheme	Expenditure Item	All Expenditure Top	All Expenditure Tail	Expenditure from Farm Power Only Top	Expenditure from Farm Power Only Tail
Uda Walawe	% Own/total	86.4	82.1	95.5	91.1
Kaudulla	% Own/total	78.1	82.7	97.0	86.1
Padaviya	% Own/total	90.9	64.3	87.9	51.7
All	% Own/total	84.8	78.3	93.2	68.4

TABLE A.5.1.7: CREDIT EXPENDITURE PER ANNUM PER NON-OWNER CLASSIFIED BY SOURCE OF FUNDS (RS)

Source of Funds	Group 1 % of Total	Group 2 % of Total	Group 3 % of Total	Group 4 % of Total	All Groups % of Total
Location: UDA WALAWE					
Friends & relatives	2.74	9.64	2.07	-	5.37
Private trader	5.68	4.64	13.75	-	6.06
Private moneylender	85.90	42.78	72.57	-	72.19
Co-operative	-	25.38	-	-	6.97
Other official sources	0.78	13.89	11.30	-	6.33
Other	4.88	3.60	0.28	1.38	3.06
TOTAL	100.00	100.00	100.00	100.00	100.00
Location: KAUDULLA					
Friends & relatives	-	73.00	-	-	45.42
Private trader	8.74	17.84	-	100.00	14.38
Private moneylender	16.79	9.14	-	-	11.98
Co-operative	15.98	-	-	-	5.99
Other official sources	54.54	-	-	-	20.44
Other	3.93	-	-	-	1.77
TOTAL	100.00	100.00	100.00	100.00	100.00
Location: PADAVIYA					
Friends & relatives	50.67	20.55	-	-	6.94
Private trader	45.57	54.65	4.27	47.50	37.47
Private moneylender	-	-	-	-	-
Co-operative	-	23.83	95.22	50.41	53.84
Other official sources	-	-	-	2.19	1.14
Other	3.75	0.94	0.50	0.15	0.61
TOTAL	100.00	100.00	100.00	100.00	100.00

In Kaudulla the picture is somewhat different. In the upper three groups incomes are relatively high compared to the off scheme farmers (Group 4). In the latter, incomes were low and expenditure high (85.8%). Thus, compared to those in the Kaudulla scheme, the living standards of non-owners in the off scheme areas are low. In Padaviya the Group 1 figure is unusually high (97.13%), an anomaly which we can explain only by some overstatement of expenditure, or understatement of incomes or both.

An attempt was made to categorise expenditure according to whether it was incurred from the farmers' own funds or from credit. The results at Padaviya and Uda Walawe schemes are particularly interesting (Table A.5.1.6). In these two schemes the poverty level increases along the scheme, and it is reflected to a certain extent in the role of credit-financed expenditure. For example, tail enders particularly at Padaviya rely on credit for a much higher proportion of expenditure than top enders. Kaudulla, the highest income location, displays a very high degree of self-financing throughout. By contrast with the non-owner sample, the proportion of credit-financed recurrent expenditure was less than 1% among owners.

A breakdown of the sources of credit shows that the major sources of funding are private sources, especially in Uda Walawe and Kaudulla (83.6% and 71.7% respectively) compared with 44.4% in Padaviya (see Table A.5.1.7), which is entirely attributable to a higher eligibility for seasonal credit there (Table A.5.3.1).

Expenditure classified by category

The hiring of labour and farm power are the biggest expenditure items in all three locations, labour amounting to one third of all expenditure (35.5%) and farm power coming a close second (30%) (Table A.5.1.8). The other major expenditure items were purchase of inputs for crop and livestock (13.5%) and repayment of credit (11.4%). These major items are considered in turn below.

(1) Hiring of Labour

In descending order of expenditure, labour has been hired for harvesting, land preparation, sowing/planting/nursery work, threshing/winnowing and for driving of buffaloes (Table A.5.1.9).

The total expenditure per non-owner for hiring of labour for agricultural operations was Rs.1,181.36, the differences between the expenditure among locations being statistically non-significant (P=0.01). The highest expenditure item was for harvesting in all the schemes amounting to 37% of the total expenditure for hiring of labour. This is not surprising since harvesting is the only operation that is done purely by manual labour, and this is one period when the demand for labour is at its peak (Figs. 4.1.1-4.1.3). Although when all locations are taken together, the three operation groups viz. land preparation, sowing/planting/nursery work, and threshing/winnowing each incurred roughly the same amounts of expenditure (i.e. some Rs.200/farm), there were slight variations among locations. For example, in Uda Walawe there was a high proportion of demand for labour for land preparation, since in Uda Walawe, most paddy land is prepared by the trampling action of buffalo hooves ('mudding') which is more labour intensive than using tractors for tilling (Appendix 4.1). In Padaviya the expenditure on labour for threshing and winnowing is very low (Rs.145.20), reflecting lower annual cropped acreages(Table 3.4.2).

TABLE A.5.1.8: MEAN ANNUAL EXPENDITURE PER NON-OWNER (RS).

Type of Expenditure	GROUP 1			GROUP 2			GROUP 3			GROUP 4			ALL GROUPS		
	Cost p.a.	No.	S.E.	Cost p.a.	No.	S.E.	Cost p.a.	No.	S.E.	Cost p.a.	No.	S.E.	Cost p.a.	No.	S.E.
I: UDA WALAWE															
Hiring in of labour	1547.14	20	147.6	1891.71	20	178.0	471.42	20	164.4	409.71	20	96.5	1080.00	80	112.7
Hiring in of Farm Power	1374.85	20	159.8	1611.42	20	156.3	298.28	20	120.0	250.28	19	75.7	891.42	79	104.4
Purchase of inputs	503.22	20	43.9	745.37	20	97.1	195.08	20	65.9	147.08	20	32.5	397.71	80	44.9
Repayment of credit	516.17	20	116.4	-	20	-	66.25	20	49.5	26.14	20	21.4	152.14	80	41.0
Repairs of farm power sources	23.57	20	27.5	-	20	-	-	20	-	-	20	-	5.89	80	6.8
Purchase of farm power sources	-	20	-	-	20	-	7.58	20	5.9	2.14	20	2.5	2.42	80	1.6
Purchase of household goods	244.37	20	46.9	394.54	20	113.4	197.05	20	112.8	70.54	20	48.4	226.62	80	45.2
TOTAL	4209.32	20	281.8	4642.88	20	365.6	1235.30	20	429.8	905.91	20	153.9	2756.22	80	272.4
II: KAUDULLA															
Hiring in of labour	1566.85	19	303.5	1290.00	19	274.9	1315.71	20	334.0	852.00	20	286.2	1251.42	78	151.5
Hiring in of farm power	1078.28	19	178.6	1230.00	19	318.2	966.85	20	231.4	610.28	20	124.4	966.85	78	113.5
Purchase of inputs	649.62	19	138.5	657.68	18	152.0	341.22	20	74.0	407.40	20	59.2	508.54	77	57.2
Repayment of credit	123.60	19	385.5	456.00	19	131.6	124.28	20	52.7	-	20	-	444.00	78	117.0
Repairs of farm power sources	16.37	19	16.3	120.60	19	48.3	163.37	20	101.0	68.57	20	80.0	92.82	78	35.4
Purchase of farm power sources	47.14	19	48.0	41.14	19	29.0	274.28	20	256.0	1364.57	20	1497.0	441.42	78	389.0
Purchase of household goods	187.71	19	77.0	930.00	19	178.1	174.00	20	193.7	68.57	20	27.2	334.28	78	81.4
TOTAL	4782.0	19	75.10	4722.85	19	799.0	3359.74	20	734.0	3371.40	20	1693.0	4038.85	78	272.4
III: PADAVIYA															
Hiring in of labour	1565.14	20	353.9	1248.00	20	148.4	1362.85	20	158.0	672.85	20	166.0	1212.00	80	117.9
Hiring in of farm power	1392.00	20	155.8	1471.71	20	240.2	1013.14	20	243.8	653.14	20	128.6	1132.28	80	106.5
Purchase of inputs	907.71	20	97.2	517.71	20	74.2	458.57	20	57.7	96.85	20	26.6	495.42	80	50.6
Repayment of credit	21.42	20	25.0	1.71	20	2.2	2184.00	20	371.9	407.14	20	164.6	653.14	80	154.5
Repairs of farm power sources	64.71	20	30.8	12.30	20	6.2	18.64	20	16.3	-	20	-	23.91	80	9.3
Purchase of farm power sources	333.60	20	374.3	1.88	20	2.2	2.31	20	2.7	-	20	-	84.42	80	93.7
Purchase of household goods	4.28	20	5.0	58.50	20	48.5	33.55	20	16.0	35.78	20	31.2	33.03	80	15.0
TOTAL	4288.88	20	600.5	3311.82	20	289.4	5073.08	20	457.0	1865.78	20	388.2	3634.23	80	277.7

Note: S. E. = Standard Error, based on expenditure per 14 months.

TABLE A.5.1.9: MEAN EXPENDITURE PER ANNUM PER NON-OWNER FOR HIRING IN OF LABOUR BY TYPE OF OPERATION (RS)

Type of Operation	UDA WALAWE Cost/ Annum	No	S.E.	% over Total	KAUDULLA Cost/ Annum	No	S.E.	% over Total	PADAVIYA Cost/ Annum	No	S.E.	% over Total	ALL SCHEMES Cost Annum	% over Total
Land Preparation	245.57	80	33.40	22.76	204.00	78	35.00	16.79	211.54	80	25.70	17.47	220.37	18.65
Sowing/ planting/ nursery work	112.28	80	13.40	10.41	231.79	78	37.00	19.00	275.91	80	40.60	22.79	2066.66	17.49
After care	45.08	80	8.00	4.17	30.38	78	14.00	2.49	24.08	80	13.60	1.98	33.18	2.80
Harvesting	393.00	80	42.90	36.43	505.25	78	64.00	41.42	394.80	80	41.40	32.61	431.01	36.48
Threshing/ Winnowing	204.68	80	27.00	18.97	229.18	78	29.00	18.79	145.20	80	19.50	11.99	193.02	16.33
Transport	1.45	80	0.60	0.13	6.94	78	3.00	0.56	21.77	80	5.40	1.79	10.05	0.85
Tending Livestock/ Buffalo etc.	-	80	-	-	10.41	78	7.00	0.86	-	80	-	-	3.47	0.29
Driving Tractor	0.68	80	0.80	0.06	-	78	-	-	15.17	80	15.60	1.25	5.20	0.44
Driving Buffalo	77.77	80	13.70	7.02	33.38	78	10.00	0.07	123.88	80	19.90	10.00	78.34	6.62
TOTAL	1080.51	80	112.70	100.00	1251.24	78	151.50	100.00	1212.35	80	117.90	100.00	1181.36	100.00

Notes: No = Number of observations; S.E. = Standard error based on expenditure per 14 months

TABLE A.5.1.10: EXPENDITURE FOR HIRING IN OF MAJOR CATEGORIES OF LABOUR PER FARMER PER ANNUM

	UDA WALAWE EXPENDITURE P.A.	NO.	S.E.	KAUDULLA EXPENDITURE P.A.	NO.	S.E.	PADAVIYA EXPENDITURE P.A.	NO.	S.E.	ALL SCHEMES EXPENDITURE P.A.
Casual Male	782.57	80	86.5	1,008.00	78	122.0	937.71	80	83.0	909.44
Casual Female	277.71	80	30.5	234.00	78	41.0	255.42	80	50.1	255.71
Casual Child	12.85	80	5.2	8.57	78	5.0	12.85	80	9.7	11.42

Notes: The standard error for values per 14 months; S.E. = Standard Error; NO = Number of Observations

TABLE A.5.1.11: EXPENDITURE PER ANNUM PER FARMER FOR HIRING IN OF FARM POWER

Main Power Types Used	UDA WALAWE Mean per annum	No.	S.E.	KAUDULLA Mean per annum	No.	S.E.	PADAVIYA Mean per annum	No.	S.E.	ALL LOCATIONS Mean per annum
4-wheel tractors	287.14	80	0.6	330.85	78	44.0	679.71	80	90.9	432.56
2-wheel tractors	395.14	80	33.5	126.00	78	46.0	136.28	80	37.6	219.14
Buffaloes	181.71	80	65.2	392.57	78	80.0	261.42	80	36.2	278.56
Bullocks with ox carts	2.57	80	1.4	41.14	78	11.0	12.85	80	3.7	48.48
Sprayers	13.71	80	1.9	8.57	78	2.0	22.28	80	4.4	14.85

Notes: No = Number of observations; S.E. = Standard Error based on expenditure per 14 months.

Differences in patterns of expenditure on labour among groups within locations reveal two points of particular interest. Firstly, in Uda Walawe, the hiring of labour for the two major operations, harvesting and land preparation, by the two top groups (Rs.757/- and Rs.418/- respectively) was much higher than that of the two bottom groups (Rs.159.80 and Rs.154.45 respectively) confirming the indication in Table 4.1.3 that bottom end farmers depend mostly on family labour. In Padaviya again the mean expenditure on the same two operations was much higher in the top three groups (Rs. 458/- for harvesting and Rs.253.90 for land preparation) than Group 4 (Rs.56.40 and Rs.84.17 respectively) supporting our view that better off farmers are the ones who hire more labour. However, in Kaudulla the differences of expenditure among groups were very marginal, showing that capacity to hire labour is more or less the same across the scheme.

Hardly any permanent labour was used for the above mentioned operations. Expenditure on casual child labour was very marginal, at about Rs.10 per annum per farmer. Casual male labour was the main expenditure item (see Table A.5.1.10), which was about Rs.909.00/per farmer per annum, compared with casual female labour which was Rs.255/- per farmer per annum.

(2) Hiring in of Farm Power

Hiring in of farm power sources emerges as a main expenditure item in all three locations, with different emphasis depending on the local conditions prevailing in a particular location. Four wheel tractors, two wheel tractors and buffaloes have been the three main power sources used. Bullocks have been hired for transport using ox carts, but not for field operations (Table A.5.1.11). The pattern of expenditure on hiring by power type observed here corresponds with non-owners' use patterns of farm power presented in Chapter 3.

(3) Purchasing of Other Farm Inputs

Table A.5.1.12 shows the breakdown of expenditure on major input items. The most important purchased farm inputs are seeds, fertiliser, insecticide and herbicides. Although the expenditure by Kaudulla non-owners is the highest (Rs.489.22 per annum), this value was not significantly different from that of Padaviya (Rs.458.14/annum) (P=0.01). The precise allocation of this expenditure by crop, land type, location and sub area within location lies beyond the scope of our present discussion. It is interesting, however, to note that if the total expenditure on farm inputs is expressed per acre of paddy cropped annually (which involves by far the largest proportion of input expenditure per farm) then the values (Uda Walawe Rs.116.68/acre, Kaudulla Rs.157.23/acre and Padaviya Rs.181.80/acre) correspond with the paddy yield rankings given in Table 3.5.1.

A further point of interest is that in Uda Walawe farmers have spent almost equal amounts on both fertiliser and herbicides and nearly 95% of herbicides expenditure and, in line with top/tail end expenditure patterns observed above, 85% of fertiliser expenditure have been incurred by the top two group farmers. One may wonder whether fertiliser is used at the wrong time, with inadequate weed control, enhancing weed growth which may have required the use of excessive quantities of herbicides. This particular point may merit agronomic investigation.

TABLE A.5.1.12: MEAN EXPENDITURE ON OTHER (MAJOR) FARM INPUTS PER FARM PER NON-OWNER

	UDA WALAWE			KAUDULLA			PADAVIYA			ALL SCHEMES
	Cost/ annum	No.	S.E.	Cost/ annum	No.	S.E.	Cost/ annum	No.	S.E.	Cost annum
Seeds	76.88	80	11.6	163.71	78	24.0	160.62	80	22.6	133.74
Fertiliser	111.94	80	14.6	191.14	78	32.0	145.11	80	18.5	149.22
Insecticides	68.82	80	10.7	74.57	78	10.0	80.48	80	11.4	74.54
Fungicides	10.37	80	3.7	24.85	78	8.0	16.28	80	6.0	17.17
Herbicides	117.94	80	17.1	15.40	78	6.0	44.22	80	10.6	59.02
Fuel, lubricants, etc.	0.25	80	0.3	19.71	78	11.0	11.40	80	10.8	10.45
TOTAL	386.22	80	44.9	489.22	78	57.2	458.14	80	50.67	444.14

Notes: No. = Number of observations; S.E. = Standard Error. These figures are based on expenditure values per 14 month basis.

Appendix 5.2: Income and Expenditure Patterns - Owner Sample

1. Income and Expenditure on Farm and Non-farm Activities not Related to the Power Source

Analysis of the income/expenditure patterns of the owner sample was disaggregated by power type owned. The categories for revenue data were as for the non-owner sample, except that no direct attempt was made to collect incomes from hiring out farm power from the owner sample, the adopted strategy being to obtain data on use-levels and convert them to revenue streams by applying the relevant hire charges.

Data already discussed have illustrated that owners have a much higher involvement in non-farming enterprises than do non-owners (Table 4.2.1) and cultivate large acreages of both lowland and highland (Tables 3.4.1-3.4.2). It, therefore, comes as no surprise that their gross earnings, even without the inclusion of revenue from hiring out power, are very substantially higher than those of non-owners.

Comparing locations, we see that Padaviya power owners have the largest off-farm (not power-related) earnings of Rs.11,849.00 per annum compared to Rs.1,542 of Uda Walawe owners and Rs.328.00 of Kaudulla owners. There were several reasons for this. First, the Padaviya sample contains a high proportion of 4wt owners who have high levels of capital at their disposal for investment in alternative enterprises. For example, in Padaviya 4wt owners earned substantial amounts from owning grinding mills (Rs.5,209.71 p.a.) and running village stores (Rs.7,832.00 p.a.), whereas in Kaudulla both these enterprises were absent and in Uda Walawe village stores earned only Rs.1,491.00 p.a. A minor component of the Padaviya 4wt earnings comprises the earnings from transport and construction contracts obtained by the Pulmuddai (off scheme) sample from the nearby Mineral Sands Corporation. Kaudulla, by contrast, is mainly a paddy area with relatively few off farm earning opportunities. Although Uda Walawe is fairly commercialised (particularly around Embilipitiya at the top end), the tractor owners rather than engaging heavily in other farm activities, made very good earnings by hiring out tractors for non-agricultural work such as the transport of straw to the Paper Mills Corporation, passenger transport and transport of building materials for contractors.

In both Uda Walawe and Padaviya the earnings of buffalo owners are half and one-fifth those of 4-wheel tractor owners respectively. This reflects the exceptionally heavy involvement of 4wt owners in non-farm enterprises at Padaviya (Table 4.2.1). But in Kaudulla the buffalo owners on average were earning nearly twice as much as 4wt tractor owners, and in Uda Walawe 2wt owners were earning more than 4wt owners. The performance of 2wt owners at Uda Walawe and of buffalo owners at Kaudulla is strongly influenced by large items under the sale of machinery and livestock heading. These may be regarded as exceptional and should not be permitted to distort the overall pattern.

Earnings by different categories

(i) From agricultural sales

The earnings from sale of crops and livestock are the highest components of gross income (Rs.6,929.00) in all the schemes, with slight differences among schemes, compared with the Rs.4,578.33 earned by non-owners. Paddy sales have, as with non-owners, been the most significant component, comprising nearly 90% of all agricultural produce sales. Variations in paddy acreage obviously affect crop sales and the overall difference in value of paddy sales between owners and non-owners corresponds with the difference in acreage (Table 3.4.1-3.4.2). Within the owner sample, however, this holds true only in certain location/power type cells. For the others it would seem that the value of crop sales does not correspond with the output levels anticipated from the yield and acreage figures we have presented, which may be due to the storage of large volumes of paddy observed among some areas. Alternatively, the sales figures may be distorted by (in the case of Uda Walawe) the sale of animsl by-products.

(ii) From off-farm activities

Compared to non-owners, the owners have a high potential for earning from off-farm enterprises other than power hire (c f. Table 4.2.1). This is reflected in the mean off-farm earnings of owners (Rs.6,929.00 per annum) compared to that of non-owners (Rs.876.00 p.a.). Perhaps in many cases initially by virtue of their privileged access to irrigation water, owners have been able to expand their land holding (Chapter 5.4) and with the capital thus accumulated have been able to venture into various enterprises such as usury, the ownership of tractors, village stores, paddy mills, undertaking construction contracts and so on. Additionally, they sometimes engage in white collar employment such as teaching, clerical work, etc. This ties in very closely when we compare the average number of years of education of a family member of more than 15 years between non-owners and owners (see Table A.5.1.4 and A.5.2.2). The mean value for non-owners was 5.49 years compared with 6.77 years for owners. Also the maximum number of years too is high in owners (16 years v. 11 years). Even among the owners we see that consistently the tractor owners have attained significantly more years of schooling than buffalo owners (P=0.05 between 4wt owners and buffalo owners).

Expenditure by different categories

Analysis of expenditure on the hiring of power sources by power owners reveals that, as was suggested above (Chapter 4.1) farm power owners are not necessarily self-sufficient in farm power (Table A.5.2.3). Buffalo owners in both Uda Walawe and Padaviya spent considerable amounts in hiring 4wt (Rs.319 and Rs.246 per annum respectively). Hiring by

TABLE A.5.2.1: AVERAGE ANNUAL GROSS REVENUE PER POWER OWNER CLASSIFIED BY REVENUE CATEGORY AND TYPE OF POWER OWNED (RS.)

Revenue Category	4wt Owners Mean per annum	No.	S.E.	2wt Owners Mean per annum	No.	S.E.	Buffalo Ownwrs Mean per annum	No.	S.E.	All Owners Mean per annum	No.	S.E.
[illegible]												
Off-farm earnings	2,945.14	5	2,185.0	1,385.14	11	716.0	220.28	8	168.0	1,321.71	24	578.0
Sale of crops & livestock	6,378.85	5	4,502.0	6,381.42	11	3,432.0	4,678.28	8	1,099.0	5,813.14	24	1,807.0
Incomes from pensions	128.57	5	150.0	19.45	11	22.7	203.57	8	187.0	103.54	24	69.7
Sale of machinery & livestock	857.14	5	1,000.0	7,636.28	11	8,909.0	128.57	8	150.0	3,721.71	24	407.8
Sale of household items	-	-	-	-	-	-	-	-	-	-	-	-
MEAN FOR GROUP	10,309.71	5	6,203.0	15,422.37	11	753.0	5,230.70	8	1,236.0	10,960.10	24	4,244.0
KAUDULLA												
Off-farm earnings	413.91	14	397.6	207.25	25	193.5	590.22	7	504.1	328.45	46	174.7
Sale of crops & livestock	3,162.00	14	1,807.0	4,593.42	25	2,162.0	3,425.14	7	2,719.0	3,980.57	46	1,344.0
Incomes from pensions	257.14	14	172.9	483.60	25	228.4	573.08	7	417.9	428.31	46	147.3
Sales of machinery & livestock	-	-	-	90.85	25	104.0	2,082.00	7	2,429.0	365.14	46	373.0
Sale of household items	-	-	-	-	-	-	-	-	-	-	-	-
MEAN FOR GROUP	3,833.14	14	2,110.0	5,373.42	25	2,102.0	6,670.45	7	2,921.0	5,101.71	46	1,369.0
PADAVIYA												
Off-farm earnings	19,730.57	20	6,945.0	11,191.00	15	7,810.0	1,293.42	14	853.0	11,849.00	49	3,863.0
Sale of crops & livestock	12,843.42	20	2,680.0	13,793.14	15	4,154.0	5,351.14	14	1,148.0	10,993.71	49	1,780.0
Incomes from pensions	737.14	20	530.0	198.85	15	166.6	266.31	14	159.3	437.82	49	227.1
Sale of machinery & livestock	4,555.71	20	3,593.0	-	15	-	30.85	14	36.0	1,868.57	49	1,492.0
Sale of household items	12.85	20	15.0	174.00	15	173.8	-	-	-	58.62	49	53.0
MEAN FOR GROUP	37,879.71	20	7,951.0	25,357.97	15	8,338.0	6,942.00	14	1,521.0	25,206.00	49	4,600.0
ALL LOCATIONS	17,340.85			15,384.14			6,281.05			13,755.93		

Notes: 1. These means are calculated from the financial flows reported by respondents. As indicated in the text (Chapter 5.3) the estimates of revenue from sale of paddy derived from this source require upward revision to allow for paddy retained but not consumed by the farm family.

S.E. = Standard Error, based on revenue per 14 months; No. = Number of Observations.

TABLE A.5.2.2: MEAN NUMBER OF YEARS OF EDUCATION ATTAINED BY MEMBERS OF OWNER HOUSEHOLDS WITHIN THE 15-65 YEAR AGE GROUP

Location	4wt Owners			2wt Owners			Buffalo Owners			All Owners		
	No.of years	No.	Standard Error	No.of years	No.	Standard Error	No.of years	No.	Standard Error	No.of years	No.	Standard Error
UDA WALAWE	7.44	20	0.68	6.57	26	0.50	6.03	19	0.48	6.68		
KAUDULLA	7.86	13	0.52	7.03	20	0.51	6.08	24	0.34	6.99		
PADAVIYA	7.36	32	0.50	6.77	23	0.59	5.82	20	0.56	6.65		
ALL LOCATIONS	7.48	65	0.33	6.77	69	0.30	5.98	63	0.26	6.77		
ALL NON-OWNERS[1]										5.49		

Notes: 1. From Tabe. A.5.1.4.
No. = Number of observations.

buffalo owners at Kaudulla was at a lower level, and was generally paid for in kind, so that such transactions are not recorded here.

The hiring of labour by owners was quite substantial, amounting to Rs.2,263/- p.a. per owner, compared to Rs.1,181/- p.a. per non-owner. The expenditure on labour by the 4wt and 2wt tractor owners was much higher than that for buffalo owners. However, on a per acre basis the expenditure by non-owners was Rs.396.35 compared with Rs.370.00 for owners.

Expenditure patterns were disaggregated by type of labour (Table A.5.2.3) and by operation (Table A.5.2.4). By contrast with non-owners, where hardly any permanent labour was employed, tractor owners (except at Kaudulla) within the owner sample spent a substantial amount on permanent labour. Both permanent male and child labour were employed (Table A.5.2.3). For example, in Padaviya, 4wt owners spent almost Rs.2,000/- on permanent adult labourers and Rs.218/- on permanent child labour per annum. The permanent male labour that was employed by 4wt owners was mostly for tractor driving, which is used for both on and off-farm work. In Uda Walawe and Padaviya where buffalo herds are large, owners have employed both permanent and casual child labour, as have those 4wt owners who also maintain buffalo. In Kaudulla the owners themselves largely look after their small herds (see Ryan et al, 1981) which is reflected by zero expenditure on child labour.

The disaggregation of expenditure on labour into individual operations reveals that tractor drivers are a significant item of expenditure for 4wt owners only. It was more than 43% of the total expenditure on hired permanent labour. Two-wheel tractors are, as repeated casual observations suggested, driven exclusively by their owners, a factor which may contribute strongly to their limited availability on the hire market, when the owners are most heavily involved in their own cropping activities.

The highest labour expenditure item (24%) at all locations is harvesting, this being an operation in which no mechanisation has taken place at all.

TABLE A.5.2.3: MEAN ANNUAL EXPENDITURE PER OWNER

I. UDAWALAWE

Type of Expenditure	4-w.t. owners			2-w.t. owners			Buffalo owners			All owners		
	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.
Hiring in of labour	2,717.14	5	1,868.0	1,866.85	11	1,109.0	1,698.85	8	508.0	1,987.71	24	617.0
Hiring in of farm power	308.57	5	360.0	340.11	11	111.5	323.57	8	801.1	328.02	24	88.5
Purchase of inputs	780.17	5	580.6	514.2	11	212.8	497.65	8	115.0	564.08	24	152.7
Repayment of credit	-	5	-	-		-	-	8	-	-	24	-
Purchase of farm power sources	85.71	5	100.0	8,247.42	11	4,056.0	-	-	-	3,798.00	24	2,066.0
Purchase of household goods	835.71	5	159.7	1,198.28	11	495.0	747.42	8	210.3	972.00	24	249.2
Total	4,727.31	5		12,166.88			3,267.50	8		7,682.60	24	

II. KAHDULLA

Type of Expenditure	4-w.t. owners			2-w.t. owners			Buffalo owners			All owners		
	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.
Hiring in of labour	437.48	14	343.7	174.42	25	162.5	83.71	7	100.0	240.02	46	137.0
Hiring in of farm power	69.18	14	80.7	-	25	-	-		-	21.06	46	20.5
Purchase of inputs	216.89	14	234.4	81.77	25	33.6	85.80	7	65.6	153.77	46	78.8
Repayment of credit	39.77	14	46.4	132.00	25	105.9	61.20	7	71.4	93.17	46	60.0
Purchase of farm power sources	-			-			-			-		
Purchase of household goods	-			-			-			-		
Total	862.28	14		388.20	25		232.70	7		509.3	46	

III. PADAVIYA

Type of Expenditure	4-w.t. owners			2-w.t. owners			Buffalo owners			All owners		
	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.
Hiring in of labour	6,494.57	20	1,277.0	4,100.57	14	1,159.0	1,401.42	14	212.0	4,310.57	48	719.0
Hiring in of farm power	274.11	20	166.2	565.45	13	168.3	276.42	14	80.3	363.94	49	89.4
Purchase of inputs	1,239.42	20	394.5	1,028.57	13	289.5	470.57	14	89.7	954.86	49	190.1
Repayment of credit	4,868.51	20	3,475.0	2,765.14	13	1,222.0	1,889.14	14	411.0	3,202.28	49	1,470.0
Purchase of farm power sources	8,861.71	20	8,409.0	60.00	13	60.0	13.71	14	11.0	3,647.14	49	3,458.0
Purchase of household goods	3,925.71	20	2,478.0	2,257.71	13	897.0	1,083.42	14	398.0	2,603.14	49	1,057.0
Total	25,668.11	20		10,777.40	13		4,534.71	14		15,081.94	49	
All locations	10,424.53	20		7,777.36	15		2,678.30	14		7,746.00	49	

No. = Number of observations

S.E. = Standard Error, based on expenditure per 14 months

TABLE A.5.2.4: MEAN ANNUAL EXPENDITURE PER OWNER FOR HIRING IN OF DIFFERENT CATEGORIES OF LABOUR

I. UDA WALAWE

Type of labour	4-w.t. owners			2-w.t. owners			Buffalo owners			All owners		
	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.
Hired permanent male	480.00	5	560.0	330.00	11	382.0	-		-	251.14	24	206.0
" " female	-		-	-		-	-		-	-		-
" " child	-		-	7.71	11	9.0	48.00	8	44.0	19.71	24	15.0
Casual male	1,845.42	5	917.0	1,130.57	11	536.0	1,247.14	8	440.0	1,318.28	24	334.0
Casual female	265.71	5	97.0	314.57	11	138.0	216.00	8	53.0	271.71	24	67.0
Casual child	126.00	5	133.0	78.85	11	77.0	140.57	8	36.0	109.71	24	47.0
All labour	2,717.13	5	1,668.0	18,666.85	11	1,109.0	1,698.85	8	508.0	1,987.71	24	617.0

II. KAUDULLA

Type of labour	4-w.t. owners			2-w.t. owners			Buffalo owners			All owners		
	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.
Hired permanent male	-		-	-		-	-		-	-		-
" " female	-		-	-		-	-		-	-		-
" " child	-		-	-		-	-		-	-		-
Casual male	432.00	14	342.6	143.14	25	128.6	85.00	7	100.0	222.00	46	126.1
Casual female	5.48	14	6.4	30.5	25	35.6	-	7	-	18.25	46	19.4
Casual child	-		-	-		-	-		-	-		-
All labour	437.48	14	343.7	174.42	25	162.50	85.71	7	100.0	240.02	46	137.0

III. PADAVIYA

Type of labour	4-w.t. owners			2-w.t. owners			Buffalo owners			All owners		
	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.	Cost per annum	No.	S.E.
Hired permanent male	1,983.42	20	453.0	792.85	15	367.0	49.71	14	41.0	1,066.28	49	253.0
" " female	-	20	-	-		-	-		-	-		-
" " child	218.57	20	169.0	-		-	112.28	14	63.0	121.71	49	72.0
Casual male	3,799.71	20	849.0	3,020.57	15	863.0	974.57	14	156.0	2,754.00	49	473.0
Casual female	445.71	20	167.0	348.00	15	223.0	218.57	14	98.0	350.57	49	99.0
Casual child	15.42	20	8.0	48.85	15	37.0	35.14	14	28.0	31.71	49	14.0
All labour	6,494.57	20	1,277.0	4,100.57	15	1,159.0	1,401.42	14	212.0	4,310.57	49	719.0

No. - Number of observations

S.E. - Standard Error, based on expenditure per 14 months

TABLE A.5.2.5: OTHER SAMPLE - EXPENDITURE PER ANNUM PER OWNER FOR HIRING OF LABOUR FOR DIFFERENT OPERATIONS

Type of operation	UDA WALAWE Cost per annum	No.	S.E.	KAUDULLA Cost per annum	No.	S.E.	PADAVIYA Cost per annum	No.	S.E.	ALL LOCATIONS Cost per annum
Land preparation	435.42	24	120.0	13.34	46	15.0	426.83	49	101.0	291.90
Sowing / planting	216.00	24	48.0	19.28	46	19.5	382.28	49	110.0	205.85
After care	133.71	24	68.0	31.11	46	33.3	337.71	49	146.0	167.51
Harvesting	474.85	24	146.0	135.25	46	70.3	1,003.71	49	226.0	537.93
Threshing / Winnowing	275.42	24	100.0	7.28	46	7.8	356.50	49	79.0	212.80
Transport	31.71	24	21.0	-	-	-	191.14	49	91.0	74.28
Tending livestock	18.85	24	22.0	-	-	-	25.71	49	12.0	14.85
Driving tractor	95.14	24	67.0	16.80	46	13.7	959.14	49	213.0	356.76
Driving buffalo	137.14	24	41.0	17.82	46	20.8	219.42	49	70.0	124.79
Other	178.28	24	0.6	-	-	-	372.00	49	1.2.0	183.42

No. = Number of observations; S.E. = Standard Error, based on expenditure per 14 months

TABLE A.5.2.6: OWNER SAMPLE: EXPENDITURE PER ANNUM PER OWNER ON MAJOR AGRICULTURAL INPUTS

Type of Input	UDA WALAWE Expenditure per annum	No.	Standard Error	KAUDULLA Expenditure per annum	No.	Standard Error	PADAVIYA Expenditure per annum	No.	Standard Error	ALL LOCATIONS Expenditure per annum
Seeds	5.19	24	6.0	27.25	46	16.4	330.00	49	100.0	120.80
Fertiliser	192.80	24	45.0	95.57	46	46.5	275.14	49	52.0	187.85
Insecticides) Herbicides &) Fungicides)	274.25	24	-	10.36	46	-	119.98	49	-	149.12
Buffalo medication	20.57	24	18.0	-			-			6.80
Buffalo feed	22.28	24	18.0	-			-			7.42
Fuel & Lubricants[1]	46.28	24	29.0	12.60	46	14.7	183.42	49	67.0	80.76

1. When tractors are hired sometimes fuel and lubricants have to be supplied, but this is very rare.

TABLE A.5.2.7: MEAN ANNUAL REVENUE/EXPENDITURE OF OWNERS FROM POWER SOURCES (RS.)

Location	Uda Walawe			Kaudulla			Padaviya			All Schemes		
Revenue/ Expenditure Item	4wt Owners	2wt Owners	Buffalo Owners	4wt Owners	2wt Owners	Buffalo Owners	4wt Owners	2wt Owners	Buffalo Owners	4wt Owners	2wt Owners	Buffalo Owners
Revenue from agriculture work	23,608.41	7,704.93	7,767.26	23,172.11	7,375.09	1,789.85	30,164.23	8,496.90	3,278.21	25,648.25	7,858.97	4,278.44
Revenue from work outside agriculture	17,818.33	1,332.31	-	14,220.29	1,130.31	-	4,700.40	1,069.91	-	12,246.34	1,177.51	-
Total Gross Revenue	41,426.74	9,037.25	7,767.26	37,392.40	8,505.40	1,789.85	34,864.63	9,566.81	3,278.21	37,894.59	8,036.49	4,278.44
Expenditure on Fuel	3,777.94	1,152.60	1,191.97	4,876.17	1,463.90	579.34	6,565.21	2,142.15	2,716.70	5,482.40	1,525.71	1,496.00
Expenditure for repairs and replacement	4,041.21	1,611.17	1,245.84	7,787.3	1,491.00	251.54	11,329.23	2,015.89	125.59	8,688.55	1,683.42	540.99
Expenditure on labour[1] for driving	2,293.75	822.50		1,959.38	647.50		1,553.13	720.00		1,935.42	730.00	
Total Expenditure	10,112.90	3,586.27	2,437.81	14,622.88	3,602.41	830.88	19,447.56	4,878.04	2,842.29	16,106.37	3,939.13	2,036.99
Net Current Revenue from Farm Power Sources	31,313.84	5,450.98	5,329.45	22,769.52	4,902.99	958.97	15,417.07	4,688.77	435.92	21,788.22	4,097.36	2,241.45
Annual Capital[2] Charge	15,552.00	3,211.00	-	10,518.00	2,602.00	-	15,200.00	4,251.00	-	14,120.00	3,310.00	-
Overall Net Revenue from Farm Power Sources[3]	15,761.84	2,239.98	5,329.45	12,251.52	2,300.99	958.97	217.07	437.77	435.92	7,668.22	787.36	2,241.45

Notes:
1. Labour is costed at Rs.25 per day for 4wt and Rs.20 per day for 2wt, the same rate being applied to family labour when driving, in order to represent its opportunity cost.
2. Derived as follows: mean tractor values at each location were calculated at the starting point of the survey, by reference to their age-structure and approximate secondhand values. Similar values were calculated for the end of the survey, so that the mean loss in value could be obtained by subtraction. To this was added the notional interest payable (at 10%) on the initial value.
3. Net current revenue minus annual capital charge.

Purchase of Farm Inputs

Across locations owners spent Rs.557.77 on purchase of inputs compared to that of non-owners who have spent only Rs.444.14. As for non-owners the highest expenditure has been for the purchase of fertilisers (Rs. 187.85) which is more than a third of the total expenditure on inputs. Apart from fertiliser inputs more than one-third of expenditure was incurred in the purchase of seeds (Table A.5.2.6).

2. Revenue and Expenditure relating to Farm Power

From Table A.5.2.7 there clearly emerge substantial differences among owners in both the net current revenue and net overall revenue. With the former, only the surplus of current incomings over outgoings is considered: the earnings of 4wt owners calculated on this basis are some 5 times higher than those of 2wt owners, and 10 times higher than those of buffalo owners. When an annual capital charge[1] is made against 4wt and 2wt, the latter emerge with lower annual net returns than buffalo owners, whereas those of 4wt owners are higher by a factor of 4.

The composition of gross revenue varies widely by location: non-farm work produces absolutely and relatively higher income than farm work for 4wt and 2wt at Uda Walawe than elsewhere, in line with the higher proportion of tractor time allocated to transport activities there (Chapter 6.2). At Padaviya, by contrast, agricultural operations account for over 80% of gross revenue. These extremes are reflected in expenditures on fuel, repair and maintenance: the relatively light work done by 4wt at Uda Walawe[2] required Rs.0.18 to be spent on these items per Rs.1.00 of gross revenue. High current costs at Padaviya and a high annual capital charge resulting from the relative low age of many tractors there, caused overall net returns to be as low as Rs.217 for 4wt and Rs.438 for 2wt. At Uda Walawe and Kaudulla, by contrast net overall returns on a 2wt were Rs.2,240 and Rs.2,301 respectively, and on a 4wt Rs.15,762 and Rs.12,251 respectively. For 2wt, this represents a net return on the average opening tractor value of approximately 20% and for 4wt, of 25%. To view these rates of return in a slightly different light, investment in a 4wt at Uda Walawe or Kaudulla would generate sufficient surplus to purchase a new one at Rs.125,000 within 7-8 years, and for a 2wt, within approximately the same period.

Appendix 5.3: Stability of Incomes

For small farms with limited cash reserves, the ability to meet cash expenditure requirements promptly (on, for example, farm power) depends not only on the aggregate annual incomes, but on the time distribution of income; further, the design of seasonal credit programmes for small farmers depends heavily on a knowledge of the time profiles of income and expenditure.

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[1] For method of calculation, see Table A.5.2.7.

[2] Even when used in agriculture, 4wt were rarely used for operations other than threshing and the transport of agricultural goods.

Our discussion in the opening pages of Chapter 5 suggested that the demise of traditional methods of sharing draught animals or paying for them in kind contributed to increased indebtedness during the cultivation season. Analysis of the time-pattern of income and expenditure among non-owners indicated that at all locations non-owners' expenditure exceeded their income by some Rs.100-Rs.200 per week for 10-15 weeks during the season. The precise extent of the deficit varied between top and tail end samples (but not systematically) and also among locations, the lowest deficits occurring at Uda Walawe.

Institutional credit was drawn upon only to a limited extent to meet these deficits: previous default had made many non-owners ineligible for seasonal loans, and fewer than 25% of non-owners received official credit, (Table A.5.3.1). The apparent serious malfunctioning of official credit schemes is nothing new, however: inadequate facilities for loan recovery, and frequent politically-motivated amnesties on outstanding loans, with their debilitating effect on farmers' motivation to repay, appear to be the main causes of this malfunction. A more efficient system could undoubtedly ease the burden of indebtedness on farmers during the cultivation season, but the search for administrative improvements offers little prospect for quick or simple solutions.[1]

Appendix 5.4: Farm Power and the Accumulation of Wealth

The effect of tractorisation on annual incomes discussed in the previous section represents merely its impact on current financial flows. A deeper analysis of its impact requires assessment of the extent to which it permits more rapid accumulation of wealth, which, in turn, can be invested to generate further income streams. One aspect of wealth accumulation was touched upon in Chapter 4 where the involvement of owners in off-farm enterprises was discussed. Here, a further important aspect, the accumulation of cultivation rights over paddy land, is discussed.

It is plausible to suggest that there is a two-way relationship between the ownership of farm power - especially tractors - and wealth. On the one hand the economic rent accumulated through advantageous access to water in major irrigation schemes forms a substantial component of the funds invested in tractors. On the other hand, the profits accruing to tractor use (especially through hiring out) are large, and permit the accumulation of further wealth. A detailed investigation of the assets comprising power owners' stocks of wealth and the pattern of their accumulation, would merit a separate study in its own right. Below we concentrate on the assets of particular relevance to the agricultural economy - the ownership and control of land. Specifically we test whether:

(i) Owners have accumulated more land over time relative to the non-owners;
(ii) Access to irrigation water within irrigation schemes has a bearing on land ownership, i.e. individuals near head of a command area are at an advantage;
(iii) Significant variations in land accumulation exist according to power type owned.

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[1] Amunugama, 1964; Central Bank, 1972; Jayaweera, 1973; Kurukulasuriya, 1971.

TABLE A.5.3.1: THE UTILISATION OF OFFICIAL SEASONAL CULTIVATION CREDIT

	Nos. Applying Success-fully	Nos. Applying but not Receiving	Nos. not Applying	Reasons for not applying					No Reason Given
				Perceived as Unnec-essary	In Default	Not Eligible	Inadequate Loan Facilities	Other Diffi-culties	
UDA WALAWE									
Non-owners	10	2	57	10	7	3	20	3	14
Owners	1	1	40	23	0	0	3	3	11
All	11	3	97	33	7	3	23	6	25
KAUDULLA									
Non-owners	8	0	57	15	34	1	6	0	1
Owners	9	2	39	14	25	0	0	0	0
All	17	2	96	29	59	1	6	0	1
PADAVIYA									
Non-owners	25	3	42	8	31	3	0	0	0
Owners	16	2	26	19	6	1	0	0	0
All	41	5	68	27	37	4	0	0	0
ALL LOCATIONS									
Non-owners	43	5	156	33	72	7	24	3	15
Owners	24	5	105	56	31	1	3	3	11
All	69	10	261	89	103	8	29	6	26

TABLE A.5.4.1: CHANGES IN OWNED LAND OVER TIME

	Acreage on Arrival			Acreage at Present		
	Acreage	No. of Observations	Standard Error	Acreage	No. of Observations	Standard Error
OWNERS	2.76	196	0.12	3.05	196	0.17
NON-OWNERS	2.74	236	0.09	2.63	217	0.09

Note: No. of observations are larger than the survey sample since multiple land types for each sample are added.

Land data on lowland, highland and chena land were collected for three time periods:

(a) at the time of arrival to the Scheme (arrival acreage);
(b) at the time of purchase of the present power type;
(c) the present acreage.

The time of arrival on the Scheme is likely to vary both by location and by individual sample member. Variations between Padaviya and Stage 1 of Kaudulla are likely to be small, since they were rehabilitated within 5 years of each other. Uda Walawe R.B. settlement started some 6 years later and took place over a period of some 7 years (Part 1 Report, Appendix II).

We might, therefore, anticipate that if wealth accumulation was to follow the same pattern at all three locations, it would be less advanced at Uda Walawe. As we discuss below, however, the pattern at Uda Walawe differed considerably from other locations.

Since land is operated under diverse tenurial forms such as owned, encroached,[1] rented in or mortgaged in, our analysis is extended to cover these different conditions. A broad cross-check on the accuracy of 'on arrival' data for lowland acreages is provided by comparing stated acreages with initial official allocations, under the blocking out of land. Data for the present period are derived from actual physical measurements, taken by the study team. All the analysis below is done for maha acreage in order to provide consistency among locations, since yala cultivation is limited in some locations.

(i) Land ownership by owners and non-owners over time

(a) All owned land (this includes all alloted land, i.e. irrigated lowland and irrigated and rainfed highland and chena land). The pattern of land ownership shows an increasing trend for farm power owners (Table A.5.4.1) which, however, is non-significant. For non-owners a slight (though, again, non-significant) decline is evident.

Uda Walawe owners were an exception to this trend, the difference being non-significant (P= 0.01). One reason for this could be that unlike the other two locations, at Uda Walawe many of those to whom land was subsequently allotted were living in areas designated for irrigation prior to the actual construction of irrigation works. With the standard land allocations granted under the Scheme, some suffered a reduction in acreage (against compensation). Also, as we have noted above (Chapter 5.2.3), several Uda Walawe owners found substantial incomes in haulage contracts for local paper mills and brick works. As we have already noted (Part 1 Report, Chapter 3.2) some two-thirds of 4wt use-time at Uda Walawe in maha 1979-80 was in non-agricultural operations. Thus the evidence suggests a diversification by tractor owners out of agriculture and into other economic activities at relatively low holding sizes.

As far as owned land is concerned the changes in land size over time within owners and non-owners is statistically insignificant (P=0.01) (see Table A.5.4.1). This is hardly surprising since one of the conditions of land allocation in irrigation schemes is that land transactions involving alloted land were illegal. Therefore, most of the land transactions have been done secretly, for example, by renting in/out or mortgaging in/out.

However, there was a slight difference between the owners and non-owners (3.05 ac. and 2.63 ac. respectively at present) which was significant only at P=0.20. One would guess that this difference is mostly through acquisition of chena land, because there was no difference in land size on arrival, and one could also assume that if people were brought to a scheme from different places they would not have had chena land at the time of arrival.

(b) Operated paddy land (includes alloted, rented in and encroached in paddy land). Because of the legal restrictions on changes in the title to land, the analysis was extended to embrace, de facto operated paddy land, which was thought likely to prove a more reliable indicator of change in wealth.[2] This provides a number of useful insights (see Table A.5.4.2).

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[1] Cultivation of Crown land illegally.

[2] This section on operated land should be read in conjunction with the notes to Table A.4.4, Appendix 4.

TABLE A.5.4.2: CHANGES IN OPERATED PADDY LAND (INCLUDING ALLOTED LOWLAND, ENCROACHED AND RENTED IN PADDY LAND) OVER TIME

Scheme		Arrival acreage			Acreage at time of Purchase of Power Source[1]			Present Acreage		
		Acres	No. of Observations	Standard Error	Acres	No. of Observations	Standard Error	Acres	No. of Observations	Standard Error
Uda Walawe	O[2]	1.70	65	0.17	3.02	64	0.87	2.15	61	0.31
	N	1.88	80	0.10	-	-	-	2.01	80	0.08
Kaudulla	O	2.33	64	0.13	4.15	64	0.26	4.82	62	0.40
	N	2.49	77	0.14	-	-	-	2.47	57	0.19
Padaviya	O	4.18	67	0.79	5.87	66	0.98	6.00	61	0.76
	N	2.55	79	0.10	-	-	-	2.52	80	0.14
All Locations	O	2.76	196	0.29	4.36	194	0.45	4.45	184	0.06
	N	2.12	236	0.06	-	-	-	2.33	237	0.13

Notes: 1. Some difficulty was encountered in obtaining uniform interpretation of this criterion in the field: the intention was to measure the change in acreage since acquisition of the present power type. Confusion arose in two ways: first, between the acreages on purchase of the present and of previous types; second, between the acreages on purchase of successive units of the present type. The accuracy of data in this category may therefore be impaired.

2. See Note of caution in Appendix 8, Table A.8.4.
O = Owners; N = Non-owners.

TABLE A.5.4.3: PADDY PLUS HIGHLAND UNDER CONTROL (OWNER, ENCROACHED, RENTED IN/OUT[1] & UNCULTIVATED)

Item		Acreage on Arrival			Acreage at Purchase of Power Source			Present Acreage		
		Acres	No. of Observations	Standard Error	Acres	No. of Observations	Standard Error	Acres	No. of Observations	Standard Error
Uda Walawe	O	3.76	65	0.46	4.56	64	1.14	3.90	65	0.45
	N	1.43	80	0.48	-	-	-	3.22	80	0.09
Kaudulla	O	4.77	64	0.1[illegible]	6.66	64	0.47	7.26	65	0.48
	N	3.69	77	0.21	-	-	-	5.25	77	0.13
Padaviya	O	6.88	67	0.87	10.70	66	1.80	11.73	66	1.75
	N	3.79	79	0.09	-	-	-	4.44	80	0.21
All Locations	O	5.09	196	0.34	7.34	194	0.75	7.65	196	0.41
	N	3.64	236	0.18	-	-	-	4.20	237	0.10

Notes: 1. This gives the net rented in acreage.

O = Owner; N = Non-Owner

First, the difference in acreage between the paddy land operated by non-owners and by owners on arrival is not significant (P=0.01), yet the present acreages are significantly different (P=0.01).

Similarly the increase in operated paddy acreage among owners is substantial and significant, whereas among non-owners it is negligible. Within individual locations the increase among the owner sample has been strongest at Kaudulla, which has also recorded the largest (though non-significant) decrease in the operated acreages of non-owners. Some de facto redistribution of cultivation rights, therefore, seems to have occurred here, which corresponds with the evidence discussed elsewhere (Chapter 3.4) of widespread informal land transactions. These points are further supported when acreages operated under rainfed conditions are added to operated paddy acreages (Table A.5.4.3), the increase in non-owners' acreages now becoming significant, which may suggest slightly heavier reliance among them on rainfed land to offset their relatively poorer access to irrigation.

(ii) Access to Irrigation Water and Land Ownership

This aspect was discussed earlier (Chapter 3.4), and it was clearly shown that non-owners near to the head works of an irrigation scheme were operating larger holdings than those near the tail end.

(iii) Land Accumulation and Power Type Owned

Three sets of land data were analysed to test whether there is a relationship between land accumulation and power type owned. The data sets included that of all land (lowland, highland and chena land under all tenurial conditions), all land excluding rented out land, and all paddy land excluding rented out paddy land.

Although there is an increase in the holding size over time with almost all the power types, the land accumulation after the purchase of power type was not significant (see Table A.5.4.4).

What is most striking is that, with the exception of Padaviya, there is little difference in the acreages cultivated at present among the owners of various power types, or in the rates at which they have accumulated land. Further, the largest increases occurred before, not after, the acquisition of the power type in question.

Data on land accumulation presented in other studies indicate more substantial acquisitions, especially by 4wt owners. Carr (1975, p.278) for instance, reports an increase since purchase of the present power type from 14.27 to 24.06 acres for 4wt and from 5.45 to 5.66 acres for 2wt owners, in the Dry Zone. In her sample of 150 4wt and 40 2wt owners it is to the former that the principal land accumulations are attributable. Both the initial acreages of 4wt owners, and their relative and absolute increase, are larger than in our sample. This may be accounted for by the fact that they are drawn from areas outside settlement schemes, and are thus unhindered by regulations governing the transfer of land in irrigated settlements. Further, the availability of water for yala cultivations among Carr's sample is limited, so that land is, on the whole, less productive, requiring larger acreages to produce returns comparable with those in irrigated settlements.

TABLE A.5.4.4: ACREAGES OF VARIOUS LAND TYPES BY LOCATION AND POWER TYPE OWNED (MAHA SEASON ONLY)

Owners of:	Time[3] Period	ALL LAND CONTROLLED[1]									PADDY LAND CONTROLLED[2]								
		UDA WALAWE			KAUDULLA			PADAVIYA			UDA WALAWE			KAUDULLA			PADAVIYA		
		Acres	No.	S.E.	Acres	No.	S.E.	Acres	No.	S.E.	Acres	No.	S.E.	Acres	No.	S.E.	Acres	No.	S.E.
4wt	Arrival	3.68	19	0.85	5.16	18	0.28	8.44	18	2.49	1.18	19	0.24	2.72	18	0.13	4.94	18	2.10
	Purchase	3.94	19	1.02	7.34	19	0.70	13.51	18	3.17	2.42	19	0.86	4.92	19	0.56	7.61	18	2.11
	Present	4.00	19	1.03	7.62	19	0.93	14.51	18	3.06	2.61	19	0.68	5.15	19	0.78	9.61	18	2.08
2wt	Arrival	2.93	23	0.50	4.22	17	0.23	5.35	24	0.40	1.69	23	0.23	2.29	27	0.18	3.31	24	0.38
	Purchase	2.82	23	0.35	5.59	26	0.59	7.48	23	1.51	2.10	23	0.28	3.57	26	0.37	4.43	23	0.89
	Present	3.28	23	0.51	6.30	26	0.51	9.32	23	1.41	2.60	23	0.52	4.57	26	0.52	5.56	23	0.99
Buffalo	Arrival	4.63	19	1.03	5.80	5	0.80	5.31	20	0.25	1.97	19	0.29	3.00	5	0.00	3.00	20	0.00
	Purchase	7.47	18	3.87	10.00	5	4.26	5.85	20	0.40	4.72	18	2.97	3.80	5	0.49	3.60	20	0.18
	Present	3.97	19	0.93	7.08	6	1.14	6.35	20	0.41	2.10	19	0.30	4.33	6	0.61	3.82	20	0.18
Non-Owners	Arrival	3.43	80	0.48	3.69	77	0.21	3.79	79	0.09	1.88	80	0.10	2.49	77	0.14	2.55	79	0.10
	Present	3.22	80	0.09	5.25	77	0.13	4.44	80	0.21	2.01	80	0.08	2.47	77	0.19	2.52	80	0.14

Notes: 1. Paddy land, highland, chena land (owned, rented in, encroached in, uncultivated - excluding rented out).
2. All paddy land (owned/allotted, rented in, encroached in, uncultivated - excluding rented out).
3. The three time periods defined correspond with owners' arrival at the study locations, their purchase of the present power type, and the current (1979/80 maha and yala) period.

These factors may account for part of the difference; a further explanation may be found in the wider scope for diversion of investment into off-farm enterprises in the more densely populated settlement areas, and for the allocation of tractor time to transport requirements arising from these and from other rural industries.[1] All of these possibilities will reduce the relative attractiveness of farming. Indeed, at one of the three study locations, net income from tractor operations greatly exceeded that from farming: at Uda Walawe, net revenues were Rs.15,761 and Rs.6,000 (approximately) from power use and farming respectively; at Kaudulla, net revenues from the two sources were approximately equal, whilst at Padaviya, the location at which land accumulation was greatest, income from farming (approximately Rs.23,000) exceeded that from farm power operations by a wide margin.

It thus seems likely that this combination of two factors, first the greater difficulty of acquiring land on settlement schemes - through both legal restrictions and the practical difficulty of managing a large number of spatially fragmented plots - and, second, the relatively greater profitability of power hire over farming in some areas, explain much of the difference between rates of land accumulation by tractor owners reported in the two studies. Certainly, some substantial accumulation did take place in the present study, especially at Padaviya, where individual cases of tractor owners controlling 40-50 acres of land were encountered. Accumulation within settlement schemes appears, however, to be proceeding more slowly than elsewhere.[2]

Finally, despite detailed safeguards, the possibility of some underestimate of land accumulation in both studies cannot be excluded: particularly within the context of legal restrictions on acquisition of settlement land in the present study, some under-reporting is to be anticipated, and so estimates of accumulation may be biased downwards.

Insofar as the data on acreages at acquisition of the present power type can be accepted as valid,[3] we would postulate the following pattern of economic activity: prior to the purchase of farm power, would-be owners are favourably placed in respect of access to irrigation water (Part 1 Report, Chapter 3.1). This gives them an advantage in yields (Table 3.5.2) on which they capitalise by the renting or mortgaging in of more irrigated land. They are also well placed to encroach on road-side or canal verges and divert irrigation water into these encroachments (for instance, at Padaviya, it has been estimated that 33% and 26% of cultivated paddy land in Tracts 1 and 2 consist of encroachments - i.e. land under irrigated paddy additional to the alloted area - whereas it is under 5% in Tract 11 and zero in Tracts 12 and 13 (Part 1 Report, Appendix II).

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[1] Including brick and paper-making at Uda Walawe, and government-funded public works at all study locations.

[2] A finding confirmed by Parker's (1979) data, indicating an increase of only 20% over initial acreage by tractor owners in the major settlement schemes under the TIMP.

[3] But see Note 1, Table A.5.4.2.

As this process of land accumulation continues, the scope for mechanisation increases and the accumulated profits are invested in a tractor. A combination of forces then encourages diversification into other enterprises: the management of further fragmented paddy plots becomes increasingly difficult;[1] the profits accruing from the hiring out of tractors are large and encourage concentration on custom work where it is available; the financial resources then become available for investment in such other enterprises as paddy grinding mills, village stores, etc.

Contrary to the experience accumulated in other countries in the region, the ownership of tractors in major irrigation schemes is not a prelude to the accumulation of land - land has already been accumulated by the time they are purchased. The ownership of tractors seems, on the contrary, to mark a transfer of attention from agricultural expansion into the development of alternative economic opportunities, particularly the hiring out of tractors for agriculture and transport purposes and the setting up of paddy mills, village stores, and various other small businesses.

Appendix

5.5: Assumptions Underlying the Calculation of Annual Capital Charges for 4wt and 2wt

Methodology

The method of calculation involved the estimation of an average opening value (i.e. at the start of the survey in 1979)of tractors at each location, their loss in value during the survey period, and the interest chargeable on the opening value at current rates. The annual capital charge is the sum of the loss in value plus the interest on the opening value.

For most of the survey period, the new purchase price of a 4wt was Rs.125,000 and of a 2wt Rs.20,000. The estimated opening values at the start of the survey and annual loss in value thereafter vary among locations according to the age structure of tractors, data on which were obtained during the survey. The average values assumed for each age group were as follows:-

		Assumed Opening Value (Rs)		Assumed Annual Loss in Value (Rs)	
		4wt	2wt	4wt	2wt
Age:	0-2 years	100,000	170,000	12,000	2,500
	3-5 years	65,000	105,000	7,000	1,500
	6+ years	35,000	5,500	3,000	800

[1] The relative uniformity of present 'all land' and 'paddy only' acreages across all owners at 6-7 acres and 4-5 acres respectively, and for 2wt and buffalo owners at Padaviya suggests that these acreages represent the management limit in normal circumstances. This limit is pushed upwards when, as in the case of 4wt owners at Padaviya, large contiguous areas of rainfed paddy land can be cultivated. On the other hand, the threshold is lower at Uda Walawe where non-farming opportunities seem particularly attractive.

Applying these assumed value to the known age structure, the following average values were obtained:

	Estimated Average Opening Value (Rs)		Estimated Annual Loss in value (Rs)	
	4wt	2wt	4wt	2wt
Uda Walawe	67,690	12,106	7,429	1,758
Kaudulla	47,941	9,827	4,765	1,423
Padaviya	66,034	15,930	7,276	2,339
All Locations	61,940	12,457	6,687	1,815

The selection of an interest rate applicable to opening values was governed by the prevailing rates charged on state-sponsored loan schemes for tractor purchase. These varied from one scheme to another, but 12% was chosen as a typical rate, giving an annual notional interest of Rs.7,433 over all schemes for a 4wt, and Rs.1,495 for a 2wt. The location-wise breakdown and a summary of the overall capital charge is presented below:-

	Average Notional Interest Charge on Opening Tractor Value (at 12% interest)		Estimated Annual Loss in Value		Total Annual Capital Charge (A+B)	
	A		B		C	
	4wt	2wt	4wt	2wt	4wt	2wt
Uda Walawe	8,123	1,453	7,429	1,758	15,552	3,211
Kaudulla	5,753	1,179	4,765	1,423	10,518	2,602
Padaviya	7,924	1,912	7,276	2,339	15,200	4,251
All Locations	7,433	1,495	6,687	1,815	14,120	3,310

No annual capital charge is made for draught animals on the grounds that under normal conditions a herd in Sri Lanka can be expected to produce enough calves over a period of years both to reproduce itself and, through sales of offspring, to cover notional interest charges on the capital invested in the herd.

Appendix

5.6: Methodology Adopted in the Calculation of Gross Revenue from Draught Power Operations

Data collection on the use of draught power was designed to exclude the recording of revenues from hiring out. It was felt that owners would be more likely to understate use levels of these were to be directly linked to a statement of their earnings. Whilst this method seems likely to produce more accurate estimates of use intensity, there remains the problem of converting these into financial flows. This was approached as follows.

Non-owners' statements of hire charges were recorded in Schedule 2 by power type, operation and acreage for each time a power source was hired in. These permitted calculation of mean per acre rates by location with the following results:

Hire Charges (Rs/acre) by operation, power type and location:-

	OPERATION:					
	1st Ploughing	2nd Ploughing	Levelling	Threshing	Winnowing	Transport (Rs/hr)
Uda Walawe						
4wt	243	96	150	133	60	50
2wt	161	52	150	-	42	10
Buffalo	231	45	107	30	-	-
Kaudulla						
4wt	215	164	150	138	60	50
2wt	294	254	75	-	42	10
Buffalo	128	77	107	51	-	-
Padaviya						
4wt	223	164	150	108	60	50
2wt	190	195	150	-	42	10
Buffalo	101	88	55	63	-	-

Owners' use of draught power for their own purposes was costed at the above rates in the same way as was custom work on the grounds that they would have had to hire in power at the prevailing rates had they not supplied it from their own stock.

APPENDIX 6: SUPPORTING MATERIAL ON THE OPERATING COSTS AND PERFORMANCE OF TRACTORS

Appendix 6.1: The Subsidy on Diesel Fuel

Diesel fuel is subsidised as part of an official policy to keep down the cost of public transport. However, since the subsidy is non-discriminatory in its incidence, there are important repercussions on the operating costs of lorry transport and tractors. In the post 1977 period the subsidy even encouraged a switch in the balance of private car imports in favour of diesel-fuelled vehicles, which was partly redressed by a separate (higher) road fund licence for diesel cars.

The precise extent of the subsidy has varied over time, as has the proportion of fuel requirements met from domestically refined crude oil. Calculation of the subsidy, in the several years when output from the local refinery was adequate in volume and composition to meet the demand for petrol and diesel, would require alteration of the refinery costs among the various outputs, which has proved impossible from the available accounting procedure. Further, in years where self-sufficiency from local refining was not achieved, these apportioned costs would have to be supplemented by the ratios of given output types (petrol, auto-diesel, heavy-diesel, furnace oil, kerosene etc.) that, within the limits of refinery design, could be extracted from the requisite volume of crude oil input. Only then would it be possible to apportion, for example, the local costs (plus imported crude oil costs) of refining some of the diesel consumed and the costs of importing already-refined diesel to the respective volumes of each consumed by the market. This, however, has been prevented, again largely by the impossibility of apportioning local refining costs among the various end-products.

We are therefore able to present only an approximate guide to the extent of diesel subsidy.

In 1979 and 1980, already-refined diesel had to be imported to meet a demand in excess of local refinery output. If we assume that the import costs reflect local refinery costs, the costs per gallon of diesel in the respective years are derived as follows:

TABLE 6.1.1: IMPORTED DIESEL COSTS IN RELATION TO RETAIL PRICES

Year	Volume of Diesel Imported (metric tonnes)	Price/ m.t. (US$)	Exchange Rate[1] (Rs=$1)	Rs/ m.t.	Rs/ gallon[2] (landed)	Rs/ gallon (at pump)	Actual Price Rs/gallon[3]
1979	198556	262.75	18.00	4729.50	18.19	20.19	7.90
1980	9923.54	287.77	20.00)				
	9924.60	329.00	20.00)	6167.70	23.72	25.72	17.25

NOTES: 1. Reflecting the shadow value of foreign exchange as adopted by e.g. IBRD and FAO.
2. A handling cost of Rs.2/gallon is added to the landed price, as advised by Ceylon Petroleum Corp.
3. Average for the full year - price changes occurred within the year.

Source: Data supplied by Budgets Section, Ceylon Petroleum Corporation.

[1] An assumption confirmed as broadly correct by the Ceylon Petroleum Corporation.

The retail prices of diesel were therefore only 39% and 67% of the costs of importing it in the respective years. Data are not available to permit extension of the analysis to earlier periods. From data on the price series of diesel and potrol supplied by the CPC in relation to world market prices of crude oil, it seems likely, however, that a subsidy on diesel of the order of 50% has been in existence at least since the fuel price increases of 1973. Certainly, the price of diesel has been roughly one-third of the retail price of petrol since 1961, and only in 1980 was it raised sufficiently to stand at more than half of the petrol price (data supplies by the Ceylon Petroleum Corporation).

TABLE A.6.2.2: PRICE VARIATIONS OF PETROLEUM PRODUCTS SINCE 1961, INLAND SALES - BULK FUELS (COLOMBO SPOT PRICE PER IMPERIAL GALLON)

Date Effective	Lanka Super Petrol Rs.cts.	Lanka Regular Petrol Rs.cts.	Lanka Super Kerosene Rs.cts.	Lanka Heavy Diesel		Lanka Auto Diesel Rs.cts.
				Low Sulphur Rs.cts.	High Sulphur Rs.cts.	
1961 27th January	3.20	3.00	1.02	0.83		1.02
8th February						1.03
14th March						
31st July						
24th November	3.16					
1962 1st January		2.98				
30th May	3.16	2.96	0.98			1.03
1st August	3.26					
25th September			1.04			
1963 15th August			0.98			
1965 10th August			0.74			
1966 27th January						1.53
1967 24th November	3.56	3.16	0.80	1.00		1.66
1970 26th October	3.81	3.41				
1971 2nd March	4.10	3.75	0.92	1.15		1.81
28th October	5.00	4.55				
1972 22nd February	5.25	4.80	1.08	1.30	1.20	
30/31st December	5.75	5.30	1.32	1.63	1.53	2.14
1973 23rd August	6.55	6.10	1.92	2.23	2.13	2.74
1974 8th January	12.50	12.00				
9th January			3.60	4.90	4.60	4.80
1975 2/3rd October	13.30	12.80	4.08	5.40	5.10	5.30
1977 14/15th March			3.48			
1978 20/21 December	20.00	18.50				
1979 13/14th June	30.00			12.00	10.30	10.50
3rd September			10.68			
1980 25th January	37.50		13.68	15.50	13.30	13.50
20th June	40.00		15.18	23.00	20.80	21.00
1981 January	42.50		18.00			27.00

Source: Budget Section, Ceylon Petroleum Corporation.

Appendix

6.2 The Costs and Benefits of Mechanisation: Exploratory Calculations

Methodology

The basic methodology is that of conventional social cost-benefit analysis.[1] The costs of importing, maintaining and using tractors is estimated on an annual basis for the years 1953-79, aggregate annual costs are subtracted from benefits, and the resultant stream of annual net benefits (disbenefits) is reduced to a present (1979) value and aggregated to give a total for the period. Since the fleet of tractors in working order in 1979 can be expected to generate cost and benefit flows at a decreasing rate for the remainder of their working lives (assumed to be a maximum of 9 years for 4WT and 5 years for 2WT after 1979), the choice of 1979 as base year for the calculation of present values involves procedures for both compounding and discounting. The annual net (dis) benefits realised prior to 1979 are compounded forward to that year, since notional interest could be earned (paid) on the net benefits(disbenefits) down to the present value year. Annual net (dis) benefits after 1979 are discounted back to the present value year. No attempt is made to account for inflation: prices are those obtaining in the respective years.

Assumptions

1. Tractor Stock Data on the annual import of 4WT by make and (in some cases) country of origin were extracted from Burch (1980, p 446), who draws on records of private importing agencies, the State Trading (Tractor) Corporation, and the annual administration reports of various government departments. For 2 WT data are drawn from the Part 1 Report, Appendix V.

2. Tractor registrations. Data by year were provided by the Registrar of Motor Vehicles (Colombo).

3. Tractors in working order Estimates were available only for certain years and assumptions, based on the volume of imports in intervening years, had to be made to fill the gaps. The available estimates include the Report of the Tractor Committee which estimated 7,308 4wt and 3,177 2 wt in working order in 1974; the FAO (1980) report, estimating 9,500 in working order in 1979 and an unconfirmed report by the Dept. of Agriculture that some 5,600 tractors were potentially repairable or working in 1963.[2] Since the volume of 4wt registered in 1979 greatly exceeds the 9,500 estimated by FAO to be in working order, a second estimate of 15,000 4 wt in working order in 1979,[3] with corresponding increases for all years back to 1964, was made.

4. The proportion of available tractor years spent in agriculture. Estimates were available from the Tractor Survey of 1974 (84%) and from FAO (1980) (72%). For 2wt, the Tractor Survey reported 96% which is widely believed to be an overestimate. The proportion was assumed to

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1. See for instance, Gittinger 1972. Income-distribution weights are not incorporated here

2. Quoted by Burch (1980) p.235.

3. The failure of owners to 'de-register' derelict tractors can be taken to account for much of the difference.

decline over time, starting from a peak of 95% in the early years when tractors were imported specifically for agricultural purposes. By 1979, following the FAO estimate, it was assumed that 28% of tractors were engaged exclusively in non-agricultural work. For 1970-76, 90% of 2wt are assumed to be working in agriculture, and, following the FAO estimate, 86% thereafter. For those 4wt based mainly in agriculture, it was assumed that part (35%) of their annual use time was spent in non-agricultural work, the remainder being divided between heavy (35%) and light (30%) agricultural work.[1] This breakdown was derived from the use patterns observed in the present study, and in Carr (1975) and Harriss (1977). For 2wt, 26% was spent in non-agricultural work, and 31% of the remainder in heavy agricultural work.

5. The costs of tractor imports. From published information (Burch, 1980; Carr, 1975; Harriss, 1977, FAO, 1980) the annual cost per tractor of imports at prevailing prices could be calculated. Years for which data gaps existed had to be filled by extrapolation. The following prices were adopted:

	4wt	2wt
1953-58	Rs.18,135	-
1958-64	19,047	-
1965-67	25,000	-
1968-70	32,000	-
1971-73	50,000	Rs.7,000
1974-77	75,000	11,000
1978	100,000	13,000
1979	125,000	17,000

Annual purchase costs were derived by multiplying these prices by the number of tractors imported. An attempt was incorporated in these prices to eliminate the distorting effect of an over-valued currency especially in the early and mid-1970s. Tractors known or supposed to have been supplied on aid grants (112 4wt from Australia in 1953; 101 4wt from UK in 1977, and some 460 4wt supplied from Russia and China in 1972-77) were assumed to have involved zero purchase cost to the Sri Lankan economy.[2]

6. Repair and maintenance. Conventional estimates (e.g. FAO, 1980) suggest that 1.3 times the initial value of a 4wt will be spent in repair and maintenance over its life. However, shortages of spare parts are known to have been severe during many periods of import restriction between 1953 and 1979. Also, the cost of labour in maintenance and repair is accounted for separately under that sub-head, so that an estimate of 40% of purchase price for 4wt is taken here.

[1] Heavy agricultural work is restricted to tilling and levelling.

[2] Implying that the opportunity cost of grant aid tied to tractors was zero, which will be an underestimate of the real cost of accepting such aid if there is any possibility of accepting other items to the same total value instead of tractors.

For 2wt, 35% against the 130% suggested by FAO, is adopted. These seem likely to be underestimates of true costs. Strictly, repair and maintenance charges should be accounted for as they occur over the lifetime of a tractor. Inadequate data on time-profiles, plus the complexity of incorporating such a refinement into the analysis, led to the simplifying assumption that all maintenance and repair costs were incurred in the year of purchase. This may lead to a slight distortion of the time profile of costs and benefits, but its overall impact on total net present value is likely to be negligible.

7. Fuel. Requirements were calculated on the basis of commonly adopted assumption rates (FAO, 1980) viz. for 4wt, 1.18 gallons/horsepower/hour for heavy agricultural work, and 0.88 gallons for transport and light agricultural work, and for 2wt, 0.182 and 0.136 gallons/hour respectively. Fuel costs per gallon were derived from data supplied by the Ceylon Petroleum Corporation, the large element of subsidy on retail prices especially during the period 1972-77 being eliminated.

8. Labour. The technique employed was to estimate the volume of labour required by tractors in driving (77 days per 4wt and 37 per 2wt per annum) non-agricultural work (40 days for 4wt and 20 for 2wt p.a.) and maintenance (20 days and 15 days respectively p.a.). These were counted as a cost of mechanisation, and were applied to tractors in agricultural and non-agricultural work. As a benefit for time spent in agricultural work, the difference in hired labour requirements between tractor and buffalo systems for the acreage ploughed annually by one tractor was taken (120 days for 4wt and 80 for 2wt). To this was added the hired labour saved from herding (75 days for 4wt and 60 for 2wt), and the work of veterinary services (5 days and 3 days respectively). Finally, it was assumed that 10% of the family labour engaged in herding and buffalo ploughing/threshing had an opportunity cost equivalent to that of hired labour, the remaining 90% having zero opportunity cost.[2] The observed mean daily wage rate for manual labour was Rs.17.50 at the study locations in 1979, although herding labour was paid less and drivers rather more.[3] The opportunity cost of labour was assumed to be Rs.10/day on an Island-wide average for 1979. This may be wide of the mark, but the relative significance of labour in overall costs is low,[4] so that any error is unlikely to influence the results strongly. Current values for the opportunity cost of labour in earlier periods were derived from available data of wage rates by assuming an opportunity in the same proportion.

9. Agricultural output. From the survey data presented in this study, and from a review of Carr's (1975) work, it seems highly unlikely that the relatively large acreages of paddy land cultivated by 4wt owners represent anything more than a transfer of land from non-owners

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[1] Both family and hired labour were included here, since the labour of tractor owners and their families appears to have an opportunity cost at least equivalent to that of hired workers.

[2] This assumption appears justified by the data; very little family labour displaced by mechanisation seems to be absorbed into other work and opportunities for leisure between planting and harvest are abundant, so that the marginal benefit of increased leisure may be low.

[3] This rate was some 10-20% higher than the corresponding Wet Zone rate.

[4] Labour costs calculated on this basis were, for instance, only 6% of fuel costs in 1979.

to owners. As such, they do not represent a net increase in cultivated area attributable to tractors,[1] and the net (dis)benefits of cultivating this land by tractor or by animal draught will be reflected only in cost differentials between the two methods. These were accounted for in the above procedures. Where an increase in acreage and in cropping intensity does seem likely is in the cultivation of rainfed crops by 4wt. The extent to which this will occur is likely to vary spatially and (in response to changing crop price ratios) temporally. A precise estimate is therefore difficult to make, but it is assumed that the additional cultivation of 10 acres of rainfed land per 4wt year, with (in 1979) a value added of Rs.500/acre, is solely attributable to mechanisation.[2] The acreage estimate is held constant over the 1953-79 period, but the value added/acre is varied according to price and market conditions over the period.[3] 2wt are not observed to generate agricultural expansion in this way, and their impact is restricted to the labour saving effect accounted for above.

10. Non-agricultural costs and benefits. These are divided into two components:

1) Benefit accruing in the transport system from tractor use. It appears reasonable to assume that the use of tractors for transport will generate benefits through both greater speed in existing transport activities and through the provision of transport where it did not previously exist. Empirical estimates of these benefits is virtually impossible in the absence of adequate time series or suitable comparative data on purely animal draught systems. From the data available, the hiring out of 4wt in transport generated a mean gross revenue of Rs.12,246 per annum (for 2wt, Rs.1,178). The - admittedly crude - assumption is made that half of these amounts represented a net contribution to transport development by the sample tractors over and above what would have been achieved by animal draught. Since the sample tractors spent only a small proportion of their use time in non-agricultural work (35% for 4wt and 26% for 2wt), a higher allowance must be made for those tractors in full time non-agricultural use. Since tractors in non-agricultural use also appear to work longer hours overall, a factor of 4 was employed for 4wt (and 5 for 2wt) in multiplying up these benefits for tractors in full time non-agricultural use.

[1] Nor are increases in yield or annual cropping intensity likely on this land.

[2] At our study locations, 4wt owners cultivated some 1.06 acres more non-irrigated land per annum than did non-owners (1.84 acres p.a. per 4 wt owner; 0.78 acres per non-owner - see Tables 3.4.1-3.4.2). This difference may be higher in areas more distant from settlement schemes where access to rainfed land may be easier. On the other hand, it is likely to be lower in the densely populated Intermediate and Wet Zones. Overall, 10 acres per tractor per year appears to be a generous estimate.

[3] For instance, although the general price level was lower in 1970 than 1979, the value added was held at Rs.500 since import restrictions in the early 1970s made the returns to cultivation of non-paddy crops particularly high. The value added attributable to tractorisation of Rs.500/acre is an estimate. It is a residual after expenses for seed, labour, fertiliser etc. have been met. Given the low yields on rainfed land (e.g. the 37/bu/acre of paddy reported in Chapter 3 at Rs.40/bu would give a gross return of only Rs.1,480/acre), this implies that one-third of gross returns is attributable solely to mechanisation, and gives a return to farm power rather higher than could be obtained from hiring out, which appears a realistic assumption.

The assumptions are thus summarised as follows:

Assumed annual contribution to trasnport activities of tractors in:	4wt	2wt
(a) mainly agricultural use	Rs. 6,000	Rs. 600
(b) full time non-agricultural use	Rs.24,000	Rs.3,000

Equivalent values were assumed at prices relevant to periods prior to 1979.

2) Secondary benefits arising from improved transport. It appears reasonable to assume that the wider and more rapid transport provived by tractors will generate further benefits both for their owners and for those hiring in tractor services. Again, empirical estimate of these benefits is difficult. As a very crude estimate, the benefits attributable in this respect to tractors over and above what animal draught would have provided are assumed to be identical to those arising in the transport system itself in 1) above, and so a reported incorporation of the aboveamounts allows for this item.

The total (primary and secondary) annual gross benefits attributable to tractor use in non-agricultural activities (at 1979 prices) are thus:

	4wt	2wt
(a) tractors mainly in agricultural use	Rs.12,000	Rs.1,200
(b) tractors in full time non-agricultural use	Rs.48,000	Rs.6,000

Appendix

6.3: Tractor Use by Age and Method of Purchase: Seasonal Use Profiles

In Table A.6.3.1 are presented age-wise summaries of tractor use intensity. These indicate a tendency for younger tractors to achieve higher use intensities overall, but the numbers of observations within individual cells are small, and the differences non-significant. Some caution in respect of this finding is therefore necessary. Variations in hours worked in different operations, however, lend some support to the notion of an age-dependent use intensity. At Uda Walawe (and to a lesser degree at Kaudulla), where non-agricultural work opportunities are relatively abundant (Part 1 Report, Chapter 3.2), it is among the younger 4wt and 2wt that use levels in those operations are higher. By contrast, the younger 4wt at Padaviya work longer in agricultural operations.

A further attempt was made to assess the influence of credit funded tractor purchase arrangements on their use intensity, the hypothesis being that the obligation to make substantial monthly loan repayments would oblige owners to use their tractors more intensively (c f. Part 1 Report, p.167 ff). The data (Table A.6.3.2) broadly confirm the hypothesis as far as 'all operations' are concerned, though, again, the numbers of observations are small and some caution in interpretation is necessary. Whilst there is no clear pattern of differences within agricultural operations, the tendency was for much of the overall difference to be explained by higher use of credit funded tractors in non-agricultural work.

TABLE A.6.3.1: MEAN ANNUAL USE HOURS PER TRACTOR BY AGE OF TRACTOR

	Age (Years)	Operation Type	UDA WALAWE Mean hours p.a.[1]	S.E.	No.of Cases	KAUDULLA Mean hours p.a.	S.E.	No.of Cases	PADAVIYA Mean hours p.a.	S.E.	No.of Cases
4wt	1-3	Agricul-	436.7	128.7	4	441.6	87.2	4	532.7	74.3	12
	4-6	tural	383.0	61.4	13	188.8	133.0	2	447.0	194.7	4
	Over 6		497.0	7.7	4	385.0	66.3	11	290.8	70.2	13
	1-3	Non-	673.6	269.8	4	368.4	207.0	4	128.3	41.8	12
	4-6	Agricul-	227.0	68.9	13	30.1	16.8	2	183.0	148.9	4
	Over 6	tural	253.1	217.4	4	248.2	84.9	11	62.9	26.3	13
	1-3	Heavy[2]	14.3	9.9	4	75.1	23.4	4	311.4	42.5	12
	4-6	Agricul-	39.4	13.6	13	21.3	4.8	2	277.2	117.9	4
	Over 6	tural	93.4	78.8	4	86.2	20.6	11	200.6	44.6	13
	1-3	All	1,110.3	181.7	4	810.0	294.0	4	661.0	92.3	12
	4-6		610.0	93.1	13	218.9	116.2	2	630.0	322.1	4
	Over 6		750.1	216.6	4	633.2	108.5	11	353.7	92.3	13
2wt	1-3	Agricul-	397.5	80.9	13	318.1	83.2	4	306.9	40.3	20
	4-6	tural	332.1	61.5	16	260.9	38.3	12	344.8	196.3	2
	Over 6		420.0	140.0	4	177.3	45.4	10	425.0	0.0	1
	1-3	Non-	155.9	39.2	13	208.0	131.0	4	101.8	25.0	20
	4-6	Agricul-	81.1	25.9	16	106.5	29.0	12	96.6	44.8	2
	Over 6	tural	114.0	62.6	4	53.2	17.7	10	174.2	0.0	1
	1-3	Heavy	170.9	62.3	13	222.0	95.4	4	247.9	30.6	20
	4-6	Agricul-	215.9	43.6	16	156.9	18.7	12	272.8	132.8	2
	Over 6	tural	260.0	106.6	4	143.2	39.1	10	256.0	0.0	1
	1-3	All	553.4	95.0	13	526.1	116.6	4	406.7	56.1	20
	4-6		413.2	76.7	16	367.4	61.4	12	441.4	241.0	2
	Over 6		534.0	102.3	4	230.5	54.3	10	599.2	0.0	1

Notes: 1. Although the survey covered a 59 week period, means are reduced to a 52 week basis. Standard errors, however, are not converted from the 59 week data period.
2. Heavy agricultural operations are defined to include only ploughing and levelling.

Whilst, again, we would stress the need for caution in interpreting the data in Tables A.6.3.1-A.6.3.2, they hint at the hypothesis that much of the apparently higher use intensity among newer tractors is largely specific to non-agricultural operations. This may result, among the more obvious possibilities, from some reluctance on the part of owners to submit new tractors to rigorous field conditions, from a bias in new ownership towards those with predominantly non-farming interests or from a flooding of the market for agricultural work.

Finally, the possibility emerges that low overall use intensities result from the aggregation of successive periods of high and low use intensity, such as might be expected to occur within the agricultural cycle. Data presented in Table A.6.3.3 for the peak land preparation and harvest periods for maha 1979-80 confirm that this is broadly the case, although of particular interest are the facts (i) that even within the peak periods use intensities of those tractors which were working were, at some 25-30 hours/week, not high, and (ii) that the inclusion of those tractors not working further reduced the means. These data suggest that there is scope for increasing the use intensity of tractors in order to reduce the consumption of irrigation water in land preparation in the ways suggested

TABLE A.6.3.2: MEAN ANNUAL USE HOURS PER TRACTOR BY METHOD OF FINANCING TRACTOR PURCHASE

	Loan Status	Operation Type	[illegible] Mean hours p.a.[1]	S.E.	No.of Cases	KAUDULLA Mean hours p.a.	S.E.	No.of Cases	PADAVIYA Mean hours p.a.	S.E.	No.of cases
4wt	Loan	Agricul-	401.9	50.2	8	259.6	194.1	3	465.1	73.7	17
	No Loan	tural	422.9	66.9	13	400.0	48.9	14	337.7	78.2	12
	Loan	Non-	325.3	64.5	8	396.0	228.6	3	130.7	44.4	17
	No Loan	Agric.	312.0	113.1	13	219.8	77.5	14	72.2	28.5	12
	Loan	Heavy[2]	49.7	21.3	8	47.3	35.6	3	282.6	43.7	17
	No Loan	Agric.	42.0	24.3	13	82.0	16.6	14	220.6	43.3	12
	Loan	All	727.2	89.1	8	655.2	410.8	3	595.8	102.4	17
	No Loan		734.9	135.4	13	619.9	103.4	14	410.0	101.9	12
2wt	Loan	Agric.	468.6	56.3	5	237.6	38.5	4	315.2	38.1	20
	No Loan		350.6	52.5	28	237.9	34.0	22	315.9	164.0	3
	Loan	Non-	163.5	36.9	5	133.8	66.4	4	105.4	24.4	20
	No Loan	Agric.	[illegible]	24.5	28	95.7	28.5	22	98.6	58.6	3
	Loan	Heavy	239.8	57.3	5	144.0	35.4	4	253.9	28.9	20
	No Loan	Agric.	197.0	39.1	28	164.8	25.3	22	227.2	109.9	3
	Loan	All	632.1	39.0	5	369.4	99.4	4	420.6	53.1	20
	No Loan		456.5	62.4	28	333.6	49.8	22	414.5	218.6	3

Notes: 1. Although the survey covered a 59 week period, means are reduced to a 52 week basis. Standard errors, however, are not converted from the 59 week data period.
2. Heavy agricultural operations are defined to include only ploughing and levelling.

in Chapter 6.4. Table A.6.3.3 suggests that increased use intensity both from expanding the working time of those tractors actually in use and from bringing other tractors into more regular use (Tables A.6.3.3-5) is possible.

TABLE A.6.3.3:

OBSERVED USE LEVELS OF FARM POWER AT PEAK PERIODS, MAHA 1979-80, BY POWER TYPE, OPERATION AND LOCATION (HRS/WEEK)

	Week No.[1]	4wt: Hrs/wk over entire Sample						4wt: Hrs/wk over those actually working[2]						2wt: Hrs/wk over entire Sample						2wt: Hrs/wk over those actually working						Buffalo: Hrs/wk over entire Sample						Buffalo: Hrs/pair/wk over those owners using buffalo					
		Uda Walawe		Kaudulla		Padaviya		Uda Walawe		Kaudulla		Padaviya		Uda Walawe		Kaudulla		Padaviya		Uda Walawe		Kaudulla		Padaviya		Uda Walawe		Kaudulla		Padaviya		Uda Walawe		Kaudulla		Padaviya	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
LAND PREPARATION	7	19	3	19	3	9	2	22	3	23	3	17	3	11	2	7	1	10	2	17	2	11	2	14	3	0	0	0	0	4	3	0	0	1	1	16	4
	8	16	2	20	3	15	3	19	2	22	3	25	3	14	3	4	1	16	4	21	3	7	2	23	4	11	4	1	0	4	2	42	4	12	4	13	4
	9	18	3	15	3	25	4	20	3	19	3	32	4	12	2	6	1	12	3	19	3	10	2	17	4	20	5	2	1	3	1	34	5	23	3	20	7
	10	17	3	8	2	20	3	22	3	12	3	26	3	12	2	6	1	14	3	18	2	11	1	17	3	22	4	8	2	4	2	56	4	15	2	23	7
	11	16	3	8	2	14	3	22	3	15	3	21	3	15	3	12	2	8	2	24	3	17	2	13	2	23	4	14	2	1	1	33	4	23	3	16	0
	12	16	3	11	3	16	3	21	3	15	3	22	3	16	3	17	3	15	3	23	3	26	3	20	3	24	4	21	3	9	3	34	3	30	3	22	5
	13	17	3	16	3	14	2	24	2	19	3	21	2	16	3	19	3	17	3	22	3	25	3	20	4	29	4	21	3	12	2	35	4	29	2	19	2
	14	15	4	9	2	18	3	25	3	13	2	30	3	16	2	21	4	25	4	22	2	28	4	28	4	21	4	22	3	24	4	32	3	28	3	29	4
	15	11	3	9	3	14	2	28	3	17	3	23	2	16	2	22	3	19	3	20	2	27	3	25	3	26	3	30	2	23	3	23	2	32	2	26	3
	16	15	3	11	3	17	2	21	3	17	2	25	2	11	2	21	3	19	3	15	2	26	3	24	3	8	2	22	2	25	3	18	3	26	2	31	3
	17	7	2	9	2	12	2	21	3	15	3	18	2	11	2	13	3	26	3	16	2	18	3	28	3	8	2	19	3	23	3	22	3	28	2	30	2
	18	11	3	7	3	12	2	16	2	18	3	17	2	10	2	10	2	17	3	16	2	17	3	20	3	7	2	13	3	21	3	23	2	27	3	25	2
	19	16	3	7	3	11	2	18	3	17	4	15	2	8	1	8	2	16	3	13	2	14	3	20	3	6	2	9	2	25	3	23	2	24	3	31	3
	20	9	3	5	2	13	2	22	3	13	2	19	2	9	2	8	2	14	3	15	2	14	3	19	3	4	2	4	1	29	3	17	2	20	5	30	2
	21	9	3	9	3	12	2	17	4	25	5	18	2	6	1	4	1	16	3	12	2	10	2	23	4	5	3	1	0	20	3	28	7	14	0	28	3
THRESHING	28	8	2	14	3	14	3	16	3	19	3	20	3																								
	29	16	3	15	3	10	2	25	3	21	2	17	3													1	1	1	0	0	0	25	0	10	3	0	0
	30	19	4	17	4	21	5	26	4	25	3	32	6													0	0	0	0	1	1	0	0	7	0	6	0
	31	17	3	17	4	18	4	23	3	23	4	30	6					n.a.[3]								0	0	1	0	0	0	0	0	11	3	9	5
	32	20	4	27	5	14	3	23	4	33	4	23	4													1	1	1	0	2	1	12	0	11	5	12	4
	33	22	3	32	6	8	2	23	3	39	5	17	4													0	0	0	0	3	1	0	0	8	1	13	1
	34	20	4	24	4	10	2	22	4	31	3	19	3													0	0	1	0	2	1	0	0	10	3	15	3
	35	12	4	18	3	9	2	23	5	23	3	18	3													0	0	1	0	8	2	0	0	19	4	13	1
																										2	1	1	0	4	1	20	7	19	4	20	5

Notes: 1. Week No. 1 = week beginning 7.8.79. 2. For definition, see text.
3. 2wt were not used for threshing.

TABLE A.6.3.4: REASONS FOR NON-USE OF TRACTORS ON A DAILY BASIS BY LOCATION (4WT ONLY)

	No. of Tractor Days Available[1]	Total No. of Tractor Days of Non-use	% Non-use	TRACTORS - DAYS OF NON-USE BY REASON[2] Reason Type 1 No.	% of all non-use	Reason Type 2 No.	% of all non-use	Reason Type 3 No.	% of all non-use
UDA WALAWE									
Peak periods[3]	4214	2267	53.80	447	19.71	1286	56.73	534	23.56
Off-peak periods	4354	2857	65.62	320	11.20	1942	67.97	595	20.83
Peak week[4]	147	82	55.78	32	39.02	38	46.34	12	14.63
TOTAL	8568	5124	59.80	767	14.97	3228	63.00	1129	22.03
KAUDULLA									
Peak periods	3409	1957	57.41	665	33.98	853	43.87	439	22.43
Off-peak periods	3521	3072	87.39	1183	38.45	1621	52.68	273	8.87
Peak week	119	67	56.30	29	43.28	20	29.85	18	26.87
TOTAL	6930	5034	72.64	1848	36.71	2472	29.14	712	14.14
PADAVIYA									
Peak periods	6398	4656	72.77	1533	32.93	2728	58.59	395	8.48
Off-peak periods	10010	7155	71.48	1809	25.28	5001	69.95	341	4.77
Peak week	280	171	61.07	88	51.46	74	43.27	9	5.26
TOTAL	16408	11811	71.98	3342	28.30	7733	65.47	736	6.23
ALL LOCATIONS									
Peak periods	14021	8880	63.33	2645	29.79	4867	54.81	1368	15.41
Off-peak periods	17885	13089	73.18	3312	25.30	8568	65.46	1209	9.24
Peak weeks	546	320	58.61	149	46.56	132	41.25	39	12.19
TOTAL	31906	21969	68.86	5957	27.12	13435	61.15	2577	11.73

Notes:

1. Reasons are grouped as follows: (1) Temporary tractor breakdown,
   (2) Work perceived to be unavailable,
   (3) Other reasons, including: long-term tractor breakdown, implement breakdown, owner not looking for work, fuel not available and bad weather.
2. i.e. No. of tractors in the sample multiplied by the number of days in the survey period.
3. For Uda Walawe and Kaudulla, a total of 29 weeks comprising 3 periods coinciding with maha land preparation, maha harvest/yala land preparation and yala harvest (weeks 7-21,28-35 and 55-60 inclusive). For Padaviya, where no yala crop was grown, a total of 27 weeks split between the first two of these categories (weeks 11-24 and 35-43 inclusive).
4. These 'peak' and 'off-peak' groupings defined above may be open to the criticism that the peak periods are too widely defined, and therefore embrace certain weeks of low activity. Reference to Table A.6.3.3 indicates, however, that the level of activity did not vary widely within the period defined. As an additional datum, levels of non-use presented here for the busiest week of the land preparation period (Uda Walawe, week 13 for 4wt and 2wt; Kaudulla, weeks 13 and 15 respectively; Padaviya, weeks 14 and 17 respectively). These indicate that non-use remains high even in the busiest week.

TABLE A.6.3.8: REASONS FOR NON-USE OF TRACTORS ON A DAILY BASIS BY LOCATION (2WT) ONLY

	No. of Tractor Days Available[1]	Total No. of Tractor Days of Non-use	% of Non-use	TRACTORS - DAYS OF NON-USE BY REASON[2] Reason Type 1 No.	Reason Type 1 % of all non-use	Reason Type 2 No.	Reason Type 2 % of all non-use	Reason Type 3 No.	Reason Type 3 % of all non-use
UDA WALAWE									
Peak periods[3]	6489	4339	66.87	1344	30.97	2118	48.81	877	20.21
Off-peak periods	6720	5041	75.01	1259	24.98	2583	51.24	1199	23.78
Peak week[4]	217	127	58.53	42	33.07	61	48.03	24	18.90
TOTAL	13209	9380	71.01	2603	27.75	4701	50.12	2076	22.13
KAUDULLA									
Peak periods	5278	3537	67.01	745	21.06	2037	57.59	755	21.35
Off-peak periods	5460	4462	81.72	831	18.62	3053	68.42	578	12.95
Peak week	182	88	48.35	51	57.95	7	7.95	30	34.09
TOTAL	10 738	7999	74.49	1576	19.70	5093	63.63	1333	16.66
PADAVIYA									
Peak periods	3636	2244	61.87	96	4.28	2007	89.44	141	6.28
Off-peak periods	5677	4278	75.36	132	3.09	4111	96.10	35	0.82
Peak week	154	73	47.40	3	4.11	54	73.97	16	21.92
TOTAL	9303	6522	70.11	228	3.50	6118	93.81	176	2.70
ALL LOCATIONS									
Peak periods	15393	10120	65.74	2185	21.59	6162	60.89	1773	17.52
Off-peak periods	17857	13781	77.17	2222	16.12	9747	70.73	1812	13.15
Peak week	553	288	52.08	96	33.33	122	42.36	70	24.31
TOTAL	33250	23901	71.89	4407	18.44	15909	66.56	3585	15.00

Notes:

1. Reasons are grouped as follows: (1) Temporary tractor breakdown,
   (2) Work perceived to be unavailable,
   (3) Other reasons, including: long-term tractor breakdown, implement breakdown, owner not looking for work, fuel not available and bad weather.
2. i.e. No. of tractors in the sample multiplied by the number of days in the survey period.
3. For Uda Walawe and Kaudulla, a total of 29 weeks comprising 3 periods coinciding with maha land preparation, maha harvest/yala land preparation and yala harvest (weeks 7-21, 28-35 and 55-60 inclusive). For Padaviya, where no yala crop was grown, a total of 23 weeks split between the first two of these categories (weeks 11-24 and 35-43 inclusive).
4. These 'peak' and 'off-peak' groupings defined above may be open to the criticism that the peak periods are too widely defined, and therefore embrace certain weeks of low activity. Reference to Table A6.3.3 indicates, however, that the level of activity did not vary widely within the period defined. As an additional datum, levels of non-use presented here for the busiest week of the land preparation period (Uda Walawe, week 13 for 4wt and 2wt; Kaudulla, weeks 13 and 15 respectively; Padaviya, weeks 14 and 17 respectively). These indicate that non-use remains high even in the busiest week.

APPENDIX 7: FERTILISER RECOMMENDATION FOR THE DRY ZONE

Since almost all the sample members used new improved varieties (NIV) the following outlines the recommended dosages and times of applications for NIVs only.

Basal Dressing: A mixture by name V1 which contains 3.0 lbs nitrogen, 30.7 lbs phosphorous and 14.4 lbs of potassium per hundredweight of mixture, to be used at the time of second ploughing or before final levelling at the rate of 1.5 cwt per acre.

Top Dressing: Urea (a nitrogen fertiliser) is recommended. For 3-3½ month varieties 2 top dressings, the first to be applied two weeks after broadcasting at the rate of ½ cwt per acre and the second at 6-7 weeks after broadcasting or four weeks after transplanting at the rate of ¾ cwt per acre. For 4-4½ month varieties a further top dressing at 10 weeks after broadcasting or eight weeks after transplanting at the rate of ¾ cwt per acre is recommended.

Thus in total the following levels are recommended per acre:

	V1	Urea
3-3½ month varieties	1½ cwt (168 lbs)	1½ cwt (168 lbs).
4-4½ month varieties	1½ cwt (168 lbs)	2 cwt (224 lbs).

APPENDIX 8: SPACE AND THE GENERATION OF SOCIO-ECONOMIC INEQUALITY IN SRI LANKA'S IRRIGATION SCHEMES

Much of our discussion in the main body of this report, and especially in Chapters 3-5, has sought to demonstrate that there are in many respects significant differences in indicators of performance and wealth[2] between tractor owners, buffalo owners and non-owners. However, the non-owner sample is, itself, heterogeneous. Our sampling scheme was stratified according to access opportunities to one key productive resource, namely irrigation water. Those with favourable access were demonstrated to obtain higher yields on larger paddy acreages than those with inadequate, irregular and ill-timed supplies. We suggest that such favourable circumstances act in substantial measure as a springboard in the process of capital accumulation with leads to tractor purchase (Chapter 5). Inequity within major irrigation - its origin and manifestations and the scope for reducing it - thus emerges as a valid area of concern, and it forms the theme of this Appendix.

A.8.1: The Context

The recent burgeoning of social scientific interest in the question of water management in Sri Lanka and in a number of other Asian countries has given additional exposure to the inequalities between what are conventionally termed 'top end' and 'tail end' cultivators on irrigation schemes. No less useful for being imprecise, the terms 'top ender' and 'tail ender' refer broadly to the distance, on gravity flow irrigation schemes, of the farmer's irrigation plot from the point at which water is issued into the channel system. More precisely, they refer to the extent of actual access to irrigation water: to the farmer's chances of obtaining an adequate, timely and reliable supply.

Most Sri Lankan irrigation schemes take the form of a storage reservoir from which water is issued through a main sluice (or sluices) to two (sometimes one or three) main channels. From there the water is delivered through a network of distributory channels and field channels to the farmer's fields. Generally speaking, 'top enders' are those with fields near the head end of the main channels, distributory channels and field channels. The precise location of the fields with the best water supply depends however on the topography and physical characteristics of each irrigation system. A farmer on a 'tail end' field channel served from a distributory channel taking off the main channel near the head sluice may have a less good water supply than a farmer served from an especially well-located distributory channel near the end of the main channel. The precise demarcation of 'top enders' and 'tail enders' is, on any one scheme, an empirical issue. However, as the information below indicates, there is not a great deal of variation. One can use as a valid rule of thumb the principle that the further water has to travel from the main sluice to the field, the less adequate and reliable is the supply.

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[1] This Appendix is attributable to M. P. Moore, (IDS, Sussex University), consultant to the Farm Power Study team in Water Management.

[2] These include: yields, fertiliser use and cultivated paddy acreages in addition to the more obvious financial differences presented in Chapter 5.

A number of social scientists, engineers and agricultural officers have for some time been aware that, on gravity flow irrigation schemes such as are found in Sri Lanka, there is a great variation between 'top enders' and 'tail enders' in the adequacy of irrigation water supply, and hence in crop yields and in income and wealth. Top enders are much more fortunate beings than tail enders. This paper attempts firstly to use some of the information generated by a number of recent research projects to throw light on the extent of this inequality in Sri Lankan irrigation schemes. The second and more important purpose is, however, to indicate the range of factors which help generate this inequality. For it is suggested below that it is not solely unequal access to irrigation water which is at issue here. There are in addition a number of other factors related to the process of developing and settling lands under irrigation projects, and to the spatial patterning of these schemes once they are complete. These settlement-related processes are particularly important in Sri Lanka, for here, more than in any other Asian country, the development of new large-scale irrigation schemes over the past half century has gone hand in hand with the settlement of new populations. Irrigation and settlement advance together.

A.8.2: The origins of inequity

It is useful to begin not with empirical data but with an elaboration of a 'pure' model of the processes generating inequality between 'top enders' and 'tail enders' in the course of development of an irrigation scheme. This model is drawn from fragments of information relating to many actual schemes. It is 'pure' in the sense that it abstracts from the particular historical, topographical or physical circumstances which shape the development of individual schemes. It focuses instead on the commonalities. To do so it is convenient to assume each new scheme is located in a hitherto unpopulated area.

For analytical convenience the factors giving rise to inequality in 'top enders' and 'tail enders' may be divided into three categories:-

i) those arising from the physical design and the management of the irrigation schemes;
ii) those arising in the process of construction and land settlement;
iii) those arising from the spatial layout of the completed system.

Each set is discussed separately below.

A.8.2.1: The physical design and management of irrigation schemes

It is the general rule in gravity flow schemes that those located hear the point of water release obtain the best and most reliable supply. Design and management can reduce but not eliminate this inequality. Unfortunately, for a number of reasons, it has not proved possible in Sri Lanka to do much to reduce these natural tendencies.

Let us take first the issue of irrigation design (including construction). Our concern is only with large-scale schemes undertaken since the 1930s. Ignoring a design innovation introduced over the past decade, and therefore able to effect (marginal) improvements in the very latest schemes and on a small fraction of the irrigation area, the important factors

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'See earlier publications arising from this study - especially Moore, (1980a) - for discussion of the implications of the Mahaweli and TIMP designs.

determining physical design since the 1930s may be schematised as follows:-

i) the prime focus was initially on the settlement aspects: the political imperative was to give a land allotment to as many families as possible. Only in the 1960s when many of the most favourable sites for irrigation development (or rehabilitation) had already been exploited did the question of the efficient use of the land become a major concern, and likewise with water in the 1970s;

ii) the schemes were designed and constructed by civil engineering cadres who were not oriented to or experienced in agriculture or irrigation water use;

iii) costs, which were almost entirely met from local funds, were to be kept as low as possible, while considerable value was placed on the provision of housing, roads and other (non-irrigation) physical infrastructure;

iv) in consequence, the irrigation channel network was constructed as cheaply as possible. The channel network was sparse and control structures few. Individual field or distributory channels were stretched to serve as large an area as possible. Channels nominally of the same status, i.e. field channels and distributory channels - were of widely differing lengths, both in total and in relation to each acre served;

v) political pressures on occasion obliged engineers to incorporate into command areas land which they knew could not be adequately irrigated given the availability of water.

The broad consequence was that it was physically difficult to supply water to some tail end areas. Some such areas, most notoriously but not only in Gal Oya scheme, have never received irrigation water.

Management might in principle have alleviated the situation despite the paucity of physical control structures. However, for a complex mixture of reasons which have been raked over elsewhere and not yet fully comprehended, there has in fact, and especially until very recent years, been very little management of water on large-scale irrigation schemes. In the extreme but not uncommon case, there is little control beyond the head sluice from the storage tank. The channel network begins to resemble a man-made river system. In this situation of de facto hydraulic anarchy (below the sluice) there is little to prevent top enders from taking the lion's share of the water available, at great cost to tail enders and to the national economy. Top enders can thus regularly harvest a better and more reliable crop, and then enjoy the benefits which greater wealth can bring: purchase of tractors, better education for their children, indulgence in politics, investment in businesses, and leasing of land from those land allottees who for financial or other reasons are unable to undertake cultivation themselves.

A.8.2.2: Factors arising in construction and land settlement

There seems little doubt that unequal access to irrigation water is the major single cause of inequality between top enders and tail enders, and for that reason has been treated first. A chronological ordering of the analysis would however dictate that one first examines the consequences of the actual construction and settlement process - since we are talking here of history rather than processes which can currently be observed, our information is less complete than we would wish. It seems however important to at least sketch out what appear to be the processes involved.

The construction process is normally 'top-down'. That is to say, work on the storage reservoir, construction of the bund, the sluices and the spill, is completed first. Then the main canal is begun, along with, or closely followed by, the distributory and field channels and the houses, roads, etc, in the paddy tracts at the top end. Last of all come the tail end tracts. One consequence is that the main construction work camp and thus very often the main town on the scheme, is located close to the main bund and thus near the head end paddy tracts. Another is that those allotted land at the head can be settled first and begin cultivation, often with generous quantities of water which has as yet no use in the undeveloped tail end tracts. Top enders obtain a head start.

This head start may be increased, if as has happened in some schemes, settlement policy changed during the construction period. Physical facilities provided for settlers have gradually been reduced over the years. The size of the standard land allotment has progressively been reduced. The policy of providing a ready-built brick and tile house has been abandoned in favour of giving the allottee a (now small) grant to help him build his own house. The allottee is no longer faced with a ready cleared and levelled paddy land plot, but asked to do the job himself, albeit with some government assistance. Among others, the Padaviya and Kaudulla (Stage I) schemes were thus affected. Their tail enders began life under extremely unfavourable conditions, and with less prospect of catching up. The resulting differences in housing and living conditions are painfully obvious to even the casual observer.

A common reaction to the evident harshness of life at tail end tracts - the inadequacy of irrigation water supplies (and thus very often scarcity of drinking water) and the need to clear and level land and build a house with own labour has been for tail end allottees to abandon or never even take up their allotments. On the tail ends of some schemes the original allottees have been replaced often to a very large extent, by people who are nominally 'encroachers'. Some encroachers have indeed eventually been given legal title to the plots to which they assumed rights. Others however remain or were for long periods without legal entitlement, and were in consequence disadvantaged through being unable to obtain certain kinds of resources from government agencies. They were for example not able even to apply for cultivation loans which, since they have on the whole not been repaid, have been a valuable source of income for those able to obtain them. Similarly, when under conditions of limited water availability in the second (yala) season cultivation has been concentrated in top end areas (the bethma system) tail end encroachers were not eligible for a share in this land.

A.8.2.3: Factors arising from the spatial layout of the completed scheme

At various points above the cumulative process of inequality inherent in normal functioning of a completed irrigation scheme is at least hinted at. One can distinguish two spatial determinants of inequality which affect particular population groups in similar but not quite identical ways: factors relating to place of residence, and factors related to place of paddy field. This distinction is necessary because one can usually find a (normally small) population which is relatively privileged on one of these dimensions and not on the other: those whose houses are located in favourable top end positions, but whose paddy fields are tail end.

Part 1 Report, Appendix 11.

The importance of residential position arises not only from the fact that the main town - and thus the site of most government offices - tends to be located towards the top end of the scheme. (There may be a second town/bazaar, but this, if large and important, is rarely lower than about half way down the scheme in distance). This spatial patterning is supported and accentuated by the road layout. Partly as a result of access requirements during construction, this tends to follow the contours of the main channel, and to focus on the main town at the top end of the scheme. External roads leading to the scheme tend to lead directly to this main town (Map A.8.1).

Transport, communications and service provisions are organised in a dove-tail fashion (Map A.8.2). Services, power, information and access to the outside world are spatially orientated in and around the head ends, especially in the head end town. It is for many reasons advantageous to live there: transport time and costs are less, it is much easier to obtain service from government agencies through personal contact and/or ability to be persistent, information of all kinds becomes available more quickly and more accurately, the greater density of population and services makes it easier, for example to obtain a private loan at reasonable interest or to find a tractor available for hire on the day required, particularly since the ownership of tractors is concentrated towards the top ends (see Part 1 Report, Chapter 3.1), there are greater chances of becoming or attaching oneself to a politically influential person, advanced education facilities are available.

All these advantages of top end living are enhanced if one has a paddy land allotment not just at the top of the scheme in general, but somewhere close to the top of the main canal. Transport time andccosts are reduced, and supervision is easy. By contrast, those with paddy allotments at the end of field channels, even if on top end paddy tract, may face longer travel and, because of the tendency of roads and paths nearer drains to get flooded during heavy rains, greater costs and obstacles in transporting farm inputs and produce or in persuading tractor owners to come for hire work. Top end residence and land location are advantageous for topographical as well as for purely spatial reasons.

A.8.3: Empirical evidence

Having sketched out the apparent causes of inequality between top and tail enders, some empirical evidence may be brought to bear - it would be ideal if one were able to separate out evidence of the fact of this inequality from evidence on the causes. In practice, however, because of the cumulative nature of the processes involved, the same sets of data are evidence on both points. No attempt is made below to separate the two.

The evidence which can be presented here is both less complete and less subtle than one might wish. Some of the most convincing is the evidence of one's own eyes when travelling around irrigation schemes. A partial substitute - sketch maps of the physical layout of a large number of irrigation schemes - cannot conveniently be reproduced here. The reader is, however, referred to Maps 1, 6 and 10 in the Part 1 Report, which illustrate that the main towns at Padaviya (Padaviya Town), Kaudulla (Medirigiriya) and Uda Walawe (Embilipitiya) each lie in the upper quarter of the command area. The sets of statistics reproduced below however indicate very clearly much the same conclusions. The authors have utilised various sets of data which have become available in the course of a number of recent and current research projects relating to irrigation water use, above all the current farm power study. In addition, special studies were made of the spatial functioning of the Kaudulla scheme (Stage I only).

This was an especially useful site at which to investigate these issues because for a number of reasons one would expect, and indeed can clearly see - less top-tail inequality here than on any other scheme of comparable size. It thus provides a rigorous test of the general ideas.

The main factors minimising inequality on the Kaudulla scheme are:-

1. The relative abundance of the irrigation water supply. As part of a developing complex (now scheduled as Mahaweli Area D), Kaudulla has not yet reached the limits of settlement development, while at the same time it has a capacious storage tank (in relation to the irrigated area) which has since 1976 been able to receive Mahaweli water from the adjacent Minneriya tank. Water is often scarce in the yala season, and tail enders receive less than top enders (see below). However, tail enders can usually depend on receiving reasonable quantities of water, at least in the maha season. The extremely smooth topography is ideal for gravity flow water distribution, while, unlike on most schemes in Kaudulla parts of the system are designed such that the drainage water from one area enters the irrigation channels serving other areas. The proportion of the water-retentive clay soil (low humic gleys) is higher than on many other irrigation schemes (cf. Part 1 Report, Maps 2, 7 and 11).

2. Unlike in the neighbouring older Minneriya scheme, where (usually) 5 acres of lowland and 3 acres of highland were granted, allotments vary from three acres of paddy and one acre of highland in Stage I (the area studied) tracts 1-6, to two acres of paddy and one of highland in Stage I, tracts 7-8, and in all of Stage II. Unlike in Minneriya, few very large accumulations of capital are in evidence among the allottee population.

3. Farm power - and the consequent opportunities for capital accumulation - is widely distributed among farming households in Kaudulla. To an unusual degree draught animals are widely distributed, singly and in pairs among farming households. Two-wheeled tractors are mainly for own use (Part 1 Report, Table 22) while four-wheeled tractors, where employed, are mainly hired from the neighbouring Minneriya scheme.

The prospects for egalitarian material progress are at least as great in Kaudulla as on any other pre-Mahaweli irrigation scheme in Sri Lanka. This relative egalitarianism is indeed in evidence in the socio-political sphere. Farm attendance at the pre-seasonal water meetings tends always to be very high compared to other schemes, and farmer participation in the meeting somewhat pronounced. This makes all the more significant the evidence below on spatial inequality within the lower main channel area (Stage I) of the Kaudulla scheme.

A.8.3.1: Location and agricultural profits

Any doubts about the fact that top end farmers consistently produce higher per acre paddy yields than tail end farmers could not survive the crushing weight of evidence generated by several recent studies. From our own study, Tables 3.5.1-3.5.2, indicate for Uda Walawe and Padaviya, where tail end water shortages are more acute than at Kaudulla, a tail end yield which is some 10 bu/ac lower than those for the locations as a whole.

TABLE A.8.1: NET RETURNS[1] PER HOUR OF FAMILY LABOUR INPUT (RS/MAN-HOUR[2]) FOR NON-OWNERS BY LOCATION AND SUB-AREA WITHIN LOCATION IN PADDY PRODUCTION

	UDA WALAWE	KAUDULLA	PADAVIYA
Top	5.65	4.79	5.31
	4.43	2.22	4.89
Tail	5.10	6.30	8.29
	1.80	5.90	3.58
ALL	3.96	4.71	5.50

Notes: 1. Derived by subtracting from the gross value of output for maha 1979-80 and yala 1980 the costs of all current farm inputs (in particular, seed, fertiliser, farm power, hired labour and crop protection materials).
2. For the derivation of man-hours, see - Notes to Table 4.1.1.

TABLE A.8.2: PRODUCTION COSTS PER BUSHEL OF PADDY PRODUCED, BY LOCATION AND SUB-AREA WITHIN LOCATION (RS)

	UDA WALAWE	KAUDULLA	PADAVIYA
Top	17.85 (25.28)[1]	16.97 (32.04)	17.00 (28.43)
	19.29 (28.31)	29.18 (48.89)	18.17 (30.11)
Tail	10.93 (21.04)	18.67 (29.49)	20.51 (27.00)
	9.70 (39.11)	9.19 (24.49)	24.64 (37.42)
ALL	15.80 (27.11)	17.00 (32.31)	19.41 (29.73)

Notes: 1. Figures in parentheses include imputed value of family labour at the following unskilled daily wage rates: Uda Walawe - Rs.11.14/day; Kaudulla - Rs.18.60/day; Padaviya - Rs.15.65/day.

The net returns from paddy cultivation per man-day of family labour input are also substantially lower at the tail ends of the same two locations than at the top ends (Table A.8.1). For Kaudulla, the returns to family labour are particularly low not at the tail end of the main channel but in the lower reaches of a distributory (RB1) feeding tract 1 (Rs.2.22/man-day) where homestead to paddy distances were long, road conditions poor, with frequent deep flooding of both paddy lands and access routes, and cultivation conditions correspondingly arduous.

Interestingly, however, tail enders appear to respond to their uncertain conditions by a substantial reduction in purchased inputs, so that when the cost of producing a bushel of paddy is calculated on the basis of purchased inputs (hired labour, farm power, fertiliser, etc.) alone, it is lower than at the top ends (Table A.8.2). The low use of purchased inputs, however, is more than compensated by high inputs of family labour, to the extent that when an imputed cost of family labour is incorporated, their costs of production per bushel of paddy become higher than at the top ends Without a more detailed analysis of the trade off between use-levels of family labour, hired labour and other inputs it would be impossible to derive optimum input-output strategies for tail enders vis-a-vis those at the top ends. What seems certain, however, is that the observed performance of tail enders conforms to some extent with what might be expected on theoretical grounds: they are producing under much greater uncertainty and on smaller farms. The risk of their being unable to repay credit for fertiliser etc. is therefore higher, so that the subjectively perceived real cost of cash inputs, once a risk premium has been incorporated, is substantially higher for them than the face value of those inputs. The relative proportion of cash: non-cash inputs required to produce a given output will be adjusted accordingly, with the result that relatively larger proportions of family labour will be employed.

Data from other studies indicating high costs of production per bushel of paddy at the tail ends incorporate similarly high imputed costs of family labour and do not refer to purchased inputs alone (Table A.8.3).

Discrepancies in top/tail end yield levels and returns to labour do not, however, provide a full measure of the differences in farming opportunities between top and tail ends. Of vital importance in widening the gap are:-

i) opportunities for encroachment involving illicit use of irrigation water. These may involve the illicit cultivation of canal, roadside and drainage reservations of land set aside for other purposes, or the conversion of allotted land designated for highland crops into irrigated paddy land. All of these opportunities are more abundant at the top than at the tail ends: at Padaviya, for instance, encroachments on reservations of various kinds, involving illicit diversion of irrigation water, are estimated for maha 1979-80 to have constituted an additional 15% over and above the allotted paddy acreage for top end tracts (1-5), 12.5% for middle tracts (6-10) and 1% for the tail end tracts (11-13) (Part 1 Report, p. 127). At Uda Walawe, some 35 acres of paddy land reserved for other purposes at the time of settlement in one top end area (tract 4) but not subsequently utilised, had by maha 1979-80 been completely encroached and irrigation supplies illicitly tapped. At Kaudulla, many of the 'highland' components of allotments at the top ends lie below canal level, thus constituting an open invitation for their conversion into irrigated paddy, which has been widely taken up.

TABLE A.8.3: THE ECONOMICS OF PADDY PRODUCTION ON THE THREE SUB-SYSTEMS OF THE GAL OYA PROJECT

Sub-System		Maha-Mandur Sub-System			Left Bank Main Channel		Gonagolla Channel	
Location		Top	Middle	Tail	Top	Tail	Top	Tail
Average yield (bushels per acre)[1]	a.	53	46	33	48	33	45	37
Cost of production (per acre	b.	1231	1155	1416	1230	1522	1106	1182
(per bushel	c.	35	49	53	30	53	29	55
Net returns per family labour day (Rs)[2,3]	d.	+27	+34	-48	+28	-11	44	-8

[1] Figures relate to the average of four seasons from Maha 1979-80 to Yala 1981.

[2] Figures relate only to the Maha 1979-80 season.

[3] These figures have been adjusted to adult male equivalents.

SOURCE: Data from a sample of 536 farmers. The figures were calculated from the forthcoming 1980 Yearbook of the Sri Lanka Water Management Project, to be published by the Agrarian Research and Training Institute, Colombo; permission to use them has kindly been given by C. M. Wijayaratne and other members of the ARTI's Water Management Group.

TABLE A.8.4: CHANGES IN THE ACREAGE OF MAHA PADDY LAND CONTROLLED[1] BY SAMPLE FOR-OWNERS BETWEEN TIME OF ARRIVAL AND THE 1979-80 CULTIVATION YEAR[2]

Scheme	Top	Top/Middle	Tail/Middle	Tail	No. of Cases	Average Acreage Increase
Uda Walawe	+17%	+36%	-29%	-36%	80	+0.13 acres
Kaudulla	-6%	-38%	n.a.	+17%	57	-0.31 acres
Padaviya	-3%	+6%	-1%	-7%	80	-0.03 acres

[1] "Controlled" = actually under control, i.e. owned, encroached or rented and mortgaged in.

[2] The interpretation of this Table requires some caution. At Uda Walawe top end, the samples consisted almost exclusively of farmers who had lived in the scheme area prior to its construction. Since the question concerning their initial land holdings used the phrase "on arrival", many of the top enders gave the acreage held in village irrigation systems prior to the construction of Uda Walawe scheme. Their acreage increases therefore partly reflect the larger paddy plots allocated under the scheme compared with what they previously held. At the tail end, however, virtually all settlers were brought in from other parts of the country, so that their acreage reductions over time reflect the difference between what they had been granted as an "irrigable" allotment and what they found actually cultivable under irrigated conditions. At Kaudulla, the upper two groups comprised almost exclusively original allottees brought in from outside the settlement area. The apparent acreage reduction for the top end group (-6%) may simply reflect the difference between their nominal paddy allotment (3.0 acres) and the acreage actually cultivable once the necessary reservations for channels, drains, bunds, paths, etc. had been deducted. It may therefore be spurious. For the middle group, cultivating under difficult conditions at the tail end of Tract 1, the change (-38%) does reflect a real subdivision of land, a consequence of the relatively low yields (Table 3.5.1) and exceptionally low returns to family labour obtainable there (Table A.8.1). The sample from Kaudulla tail end (Tract 8), consisted exclusively of original allottees, and the increase in paddy holdings (+17%) is attributable in equal proportions to encroachments and to the renting in of land. At Padaviya, the upper three groups consist entirely of original allottees, their acreage changes being negligible for much the same reason as discussed for the top group at Kaudulla. The tail end group, however, consists partly of post-settlement newcomers who had no land on arrival, so that the "initial acreage" is biased downwards from 2.6 acres of paddy allotted. Therefore, whilst our percentages show only a small decrease in mean cultivated paddy area, the fact is that there has been substantial abandoning and subdivision of paddy land in this tract for much the same reason as advanced above for the second group at Kaudulla.

ii) Virtually as a corollary to i), the acreages to which irrigation water cannot be conveyed at the tail ends - comprising both complete allotments or parts of allotments - are relatively higher than at the top. Thus, at Uda Walawe, the majority of blocked-out land in tract 19 cannot be supplied with irrigation water. At Padaviya acreages officially recognised as unirrigable or abandoned comprise 9% of allotted paddy land in tracts 1-5, 7% in tracts 6-10 and 38% in tracts 11-13. (Part 1 Report, p. 127). Thus not only is the reliability of water supply to the irrigable parts of the tail ends poorer, both the irrigable and highland acreages cultivated per farm are smaller (cf. also Table 3.4.2). As discussed elsewhere with specific reference to the tail end of Uda Walawe (Farrington, 1979), under current standards of cultivation, irrigated paddy provides higher returns to land and labour than other crops in those limited areas where it can be cultivated. Farmers will thus concentrate their efforts (and, as we have seen, much of their family labour) on paddy, and other crops will be cultivated only on a small scale for two reasons: first, low returns and, second, the absorption of family labour in both paddy cultivation and in the search for off-farm earnings (cf

We must conclude that the advantages in agricultural production and profitability held by top enders over those at the tail ends are largely attributable to their more favourable access to irrigation water. The situation corresponds precisely to that encapsulated in the classical economic concept of land rent. The owner of the more productive land (the top ender) obtains an unearned increment ('rent') by virtue of the fact that he happens to be the owner, and not by virtue of any special effort on his part.

A.8.3.2: Location and Capital Accumulation

It would be surprising if the higher profits obtained through paddy production at the top end of schemes did not result in greater capital accumulation in the hands of top end cultivators. The available data do not surprise. One set, published elsewhere by the present authors and therefore not reproduced here, indicate a very close connection between location and ownership of farm power, especially the more remunerative types of farm power, which, through hire, themselves contribute strongly to further capital accumulation. Ownership of four-wheeled tractors, and, to a lesser extent, the much less expensive two-wheeled tractors, is strongly concentrated at the top ends of the schemes studied - Uda Walawe, Padaviya and Minneriya (Part 1 Report, Chapter 3.1). Only in Kaudulla - which is anyway much more egalitarian in a locational sense, and partly dependent on hire of four-wheeled tractors from Minneriya (see above) - is this relationship not present. There is no such pattern in the case of the ownership of the much less expensive and less profitable source of farm power, namely draught animals. Their distribution is anyway very much affected by access to grazing land[1], and in this tail ends may often have an advantage.

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[1]Especially in those locations where 'extensive' animal husbandry systems are practised -

A second index of capital accumulation is control, whether through purchase, encroachment, mortgage or leasing, of increased land holdings. As we have already noted from tract-wise data at Padaviya, the scope for irrigated encroachment is larger at the top than at the tail ends, as it is for the gravity irrigation of areas officially designated as 'highland' at Kaudulla. However, dramatic increases in land holdings are rare in Sri Lankan irrigation schemes. This is not so much because of the widely flouted and indeed virtually unenforced legal restrictions on sub-division, leasing, mortgaging in and sale of hominally remains Crown property. Rather it is because the pressure of population on irrigated land and the paucity of non-agricultural employments makes allottees tenacious in holding on to their land whenever possible. Those who wish to accumulate large paddy holdings - such as owners of 4wt who have the capacity to till them - and those especially immune from legal or communal sanctions, such as government officers - generally have to look outside the command area (as did 4wt owners at Padaviya - see Chapter 3.4), although some may obtain largish holdings within the command area (Table 3.4.1). It is not therefore surprising that, as the figures in the last row of Table A.8.4 reveal, actual changes in paddy land areas cultivated by allottees since settlement are on average very low. If we discount part of the increase at the top end of Uda Walawe as spurious (Note 2), the actual increases in acreage there and elsewhere are small. Decreases in cultivated acreage are attributable both directly to the failure of water supply (Uda Walawe, tail end) and to sub-division of land as a result of economic difficulties (Kaudulla, tail end of tract 1; Padaviya, tail end) which can be traced back in large measure to irrigation inadequacies.

One form of investment which is unconstrained by the legal and practical problems faced in obtaining additional land or purchasing tractors is improvements to housing. Housing standards have elsewhere in Sri Lanka[1] been found to be a reliable if crude index of general income and wealth. In those cases where all colonists were originally provided with the same standard two-roomed colony house, further construction should provide a good idea of relative rates of improvement in income. The relevant data are available only in relation to a sample of twenty six allottees on the Kaudulla scheme. These allottees divided equally between those with paddy land at the top of Tract 1, and those with land at the very tail end of this long tract, who are in relation to water supplies almost as much tail enders as those with fields at the end of the main channel. The results conform to the general model. Since settlement in about 1960 top enders had added on average 2.4 rooms to each house, and tail enders only 1.4 rooms. (It may be useful to mention here that this top end sample have paddy lands located within an average of about half a mile from their houses, approachable on all-weather, if unsurfaced, roads. By contrast, tail end farmers are obliged to travel on average about four miles to their fields, the last half mile or so on roads which are badly eroded and impassable except on foot - and with difficulty - in the rainy season.

A.8.3.3: Location and Services

It has already been suggested above that government offices and other services on irrigation schemes tend to be concentrated in towns or villages near the top end. This general point, so obvious to the eye, could only be substantiated on paper after an exhaustive census which the present authors have not had the resources to conduct. Some more readily available

[1] Moore and Wickramasinghe (1980).

TABLE A.8.5: LOCATION OF THE HOUSES OF SELECTED GOVERNMENT OFFICERS IN THE KAUDULLA SCHEME (STAGE I) IN RELATION TO POPULATION

Residential Location[1]	No. of Officers from Selected Categories[2] Resident in the Locality	Estimated Total No. of Households[3]	No. of Households per Officer Resident
A - Top	34	1329	39
B - Middle	8	570	71
C - Tail	2	913	457
TOTAL	44	2812	64

[1]See Map 4 A.8.2.

[2]The officers selected were the 'field' and supervisory (i.e. non-office) staff of those departments which have the greatest influence in matters connected with agriculture and land: the Regional Manager of the Agricultural Development Authority, Agricultural Instructors and field extension staff of the Department of Agriculture; the field staff of the Land Commissioner's Department; the Assistant Government Agent and Grama Sevekas; the Divisional Officer and Cultivation Officer of the Regional Services Department; the Technical Assistant and field staff of the Irrigation Department, bank managers and police officers.

[3]Encroachers are included. The figures are however necessarily approximate.

SOURCE: Data collected in the Farm Power Study, mainly by R. Amerakoon with the kind assistance of the Colonisation Officer and his staff.

TABLE A.8.6: LOCATION OF THE PADDY FIELDS CULTIVATED BY SELECTED GOVERNMENT OFFICERS IN THE KAUDULLA SCHEME, STAGE I

Location of Paddy Lands		No. of Plots[1] cultivated by Selected Officers[2], Maha 1981-82 Season	No. of Plots cultivated by Officers per 1,000 acres of paddy land
Top	Tracts 1-3	15	6.5
Middle	Tracts 4-6	5	5.8
Tail	Tracts 7-8	3	2.1
TOTAL		23	5.0

[1]Separate plots cultivated by the same person have each been treated separately.

[2]Officers as in Table A.8.5.

NOTE: Incomplete information on the size of these plots suggests that they tend to be larger nearer the tail end. Note also that several plots cultivated by officers resident in and serving Stage I of the scheme were located at the top end of Stage II.

SOURCE: Farm Power and Water Use Study.

TABLE A.8.7: PUPIL-TEACHER RATIOS IN SCHOOLS IN THE PADAVIYA SCHEME ACCORDING TO LOCATION, 1979

Location	No. of Pupils per teacher in Schools Serving the Locality	
	Upper Main Channel	Lower Main Channel
Top, i.e. Padaviya town area	30[1]	
Middle	31[2]	34[3]
Tail	47[4]	48[5]

1=Tracts A + B of Upper Main Channel (UMC) and Tracts 1-4 of LMC; 2=Tracts C + D;
3=Tracts 5-10; 4=Tract E;
5=Tracts 11-13.

SOURCE: Agrarian Research and Training Institute, "Study of Five Settlement Schemes Prior to Irrigation Modernisation , Vol. 5, Padaviya, "Research Study No. 39, Colombo, 1980, p.8.

TABLE A.8.7: DENSITY OF VOLUNTARY ASSOCIATIONS ACCORDING TO POPULATION IN RESIDENTIAL AREAS, KAUDULLA (STAGE I) 1981

Residential Location[1]	No. of Voluntary Societies[2]	Average No. of Households per Society	Estimated Percentage of Households Resident on Encroached Land
A - Top	22	60	35%
B - Middle	7	81	17%
C - Tail	9	101	25%
TOTAL	36	78	28%

[1]See Map 2

[2]Includes Rural Development Societies (10), Women's Rural Development Society (1), Death Donation Societies (also serving as credit societies)(9), Buddhist Societies (3), United National Party branches (5), Sri Lanka Freedom Party Branches (3), Sarvodaya Societies (5) and Community Association (1).

SOURCE: Farm Power and Water Use Study.

information however throws light on aspects of the general pattern, especially in relation to government institutions.

On the Kaudulla scheme, government offices are heavily concentrated in and around Medirigiriya town, with a few secondary facilities at Diyasenapura (Map A.8.2). The location of the houses of government officers and of the paddy fields they cultivate reveals a similar pattern of concentration (Table A.8.5). This information relates only to a small fraction of those persons occupying government posts on Stage I of the scheme. They are however the more powerful persons with significant influence over agricultural and land matters, and thus the important officers from the farming point of view.

These same officers are in most cases - and in a formal sense - illegally themselves engaged in cultivating paddy land, mainly but not only within irrigated lands on the scheme. Of the forty seven officers identified, forty four resided on the scheme, and thirty four (72%) were identified as paddy cultivators. These officers between them cultivated twenty three plots of irrigated land in the Stage I area. As Table A.8.6 shows, their plots were heavily concentrated in the top end paddy tracts. Thus, in their extra-official as well as in their offical roles these officers find their activities focused on the top end of the scheme. There are few reasons for them to visit the tail ends or to enter into social and economic relationships with the people living and cultivating there. Contact with officers is easier for top enders.

The information in Table A.8.6 on pupil-teacher ratios in different parts of the Padaviya scheme illustrates a different aspect of inequality in service provision. Regardless of any spatial inequality in the provision of schools - and on this we have no reliable data - the quality of the education provided, as measured by the ratio of teachers to pupils, is higher at the top ends and lowest at the tail ends. This finding conforms precisely to the widely observed situation in much of Sri Lanka. Schools and other public facilities located in places which are more desirable from the staff's point of view - i.e. near towns and public transport - are better staffed than the more remote and less attractive locations.

A.8.3.4: Location and Socio-political Organisation

The superior wealth of top end populations and their closer spatial and social interaction endows them with greater political power. Table A.8.7 suggests that, on the Kaudulla scheme, this is matched by more effective socio-political organisation. The density of voluntary and political associations in relation to population increases from tail to top of the scheme.

Another corresponding set of data is the socio-economic status of those individuals identified as local leaders by a sample of farmers cultivating in the top most and bottom most paddy tracts respectively:

Characteristics of identified top end leaders (tract 1):

Mr. A. - Justice of the Peace, Director of the Multipurpose Co-operative Society, Chairman of the United National Party Branch;

Mrs. B. - Chairwoman of the Women's Rural Development Society, Secretary of the Sarvodaya Society, Chairwoman of the Gramodaya Mandalaya, prominent member of the United National Party, wife of a 'Contact Farmer';

Mr. C. - Vel Vidane, prominent member of the United National Party, owner of a four-wheel tractor and a lorry, paddy trader.
Mr. D. - Chairman of the Rural Development Society, Secretary of the Sarvodaya Society, shop owner.

Characteristics of identified tail end leaders (Tract 8):-
Mr. E. - Chairman of the United National Party branch, ordinary farmer.
Mr. F. - Former Chairman of the Rural Development Society, owner of a two-wheeled tractor, ordinary farmer.
Mr. G. - Chairman of the Rural Development Society, Secretary of the Buddhist Society, ordinary farmer.
Mr. H. - Vel Vidane, Chairman of the Buddhist Society, ordinary farmer.
Mr. I. - Vel Vidane, Secretary of the Sri Lanka Freedom Party branch, Chairman of the Death Donation Society, ordinary farmer.
Mr. J. - Chairman of the United National Party branch, Secretary of the Death Donation Society, ordinary farmer .

Leaders from the top end have appreciably more wealth and occupy more and more powerful formal positions than do those from the tail end.

A.8.4: Conclusions

Space is undoubtedly a very significant factor in the emergence of socio-economic and socio-political inequalities in irrigation settlement schemes. The information given here is incomplete in a number of respects. It would be interesting to know not only how far but also exactly why top enders are able to take advantage of their locations, power and contacts with government officers to obtain privileged access to publicly-allocated resources: official credit, seed of new paddy varieties, allocation of land under the 'bethma' system, etc. More fundametally, how far are the inequalities recorded here between tops and tails the result of mechanisms set in train in the settlement process, and how far do they arise from pre-existing inequalities? How widespread was the phenomenon of more powerful, acute or wealthy allottees using their resources to ensure that they obtained top end land allotments during the initial land allocation process?

Such questions might be regarded as being purely of historic or academic interest. Unfortunately, for those concerned with the more immediate policy implications there are few direct recommendations which could be made. Policies to improve water management or to direct farm power investments to draught animals rather than to four-wheeled tractors could be expected to dampen the process of differentiation into wealthy top end and poor tail end populations. The process itself is however powerfully rooted in almost 'natural' spatial processes. It is too late, except perhaps on the yet undeveloped Mahaweli lands, to re-design schemes such that public facilities and private trade and other services are directed towards tail ends. Only the most optimistic would see any prospect of shifting the spatial balance of these activities on existing schemes. There are topographic as well as socio-political obstacles, on top of the weight of inertia and resource scarcity.

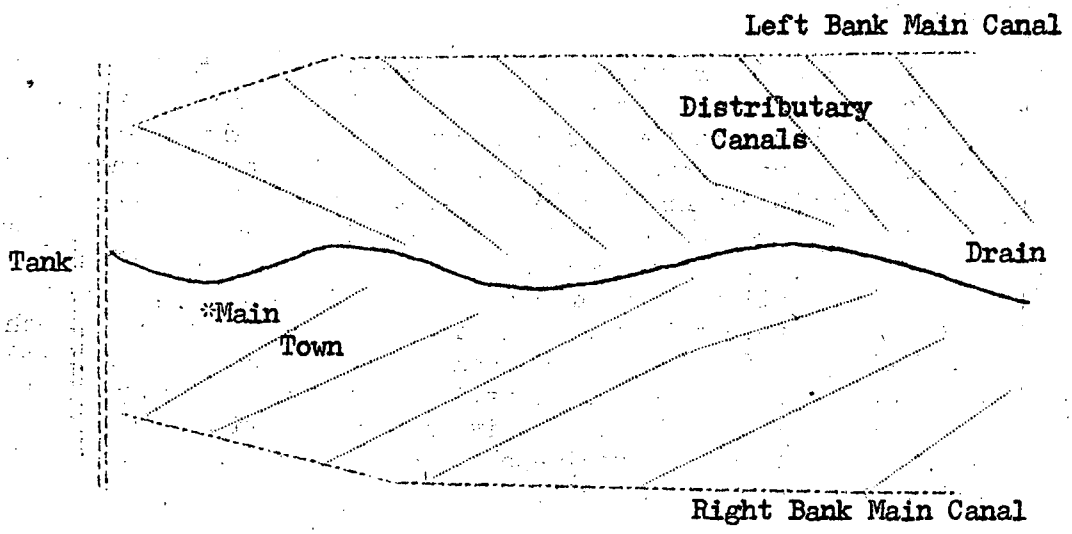
It is perhaps to the academic social scientist rather than to the practical policy maker that these results will be of special interest. For they raise a number of questions related to the as yet inadequately researched (or even debated) questions of the dynamics of capitalist development and socio-economic differentiation in Sri Lanka's Dry Zone agriculture. In the first place perhaps they reveal the need to go beyond an analysis of abstract economic relationships between different

classes or socio-economic categories and to take into account two further major sets of variables affecting the process of differentiation: space and the state. Differentiation has an important spatial dimension which is at the same time mediated by access to the personnel and services of state agencies. For it was within state institutions that decisions about the inter-personal allocation of land plots was first made, and it is within the context of state allocation of valuable resources (land title, de facto permission to encroach, fragment or lease land and to 'illegally' appropriate additional irrigation water, allocation of agricultural credit, of the right to purchase individual tractors and of land under the bethma system) that the 'natural' inequality arising from spatial location is exacerbated.

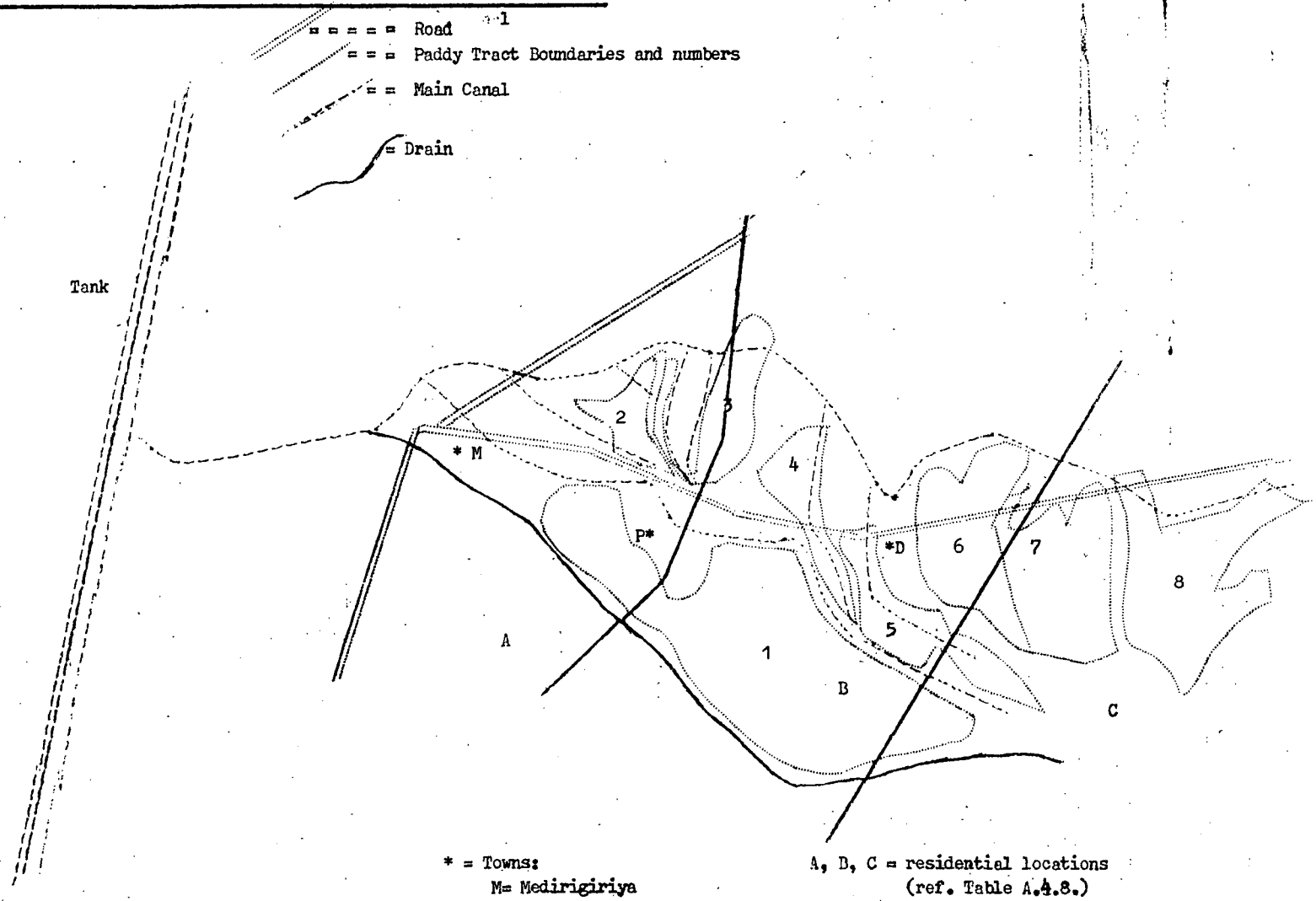
In the second place, this study suggests the importance of fortuitous or politically-mediated access to desirable land and house sites in the process of capital accumulation within agriculture. 'Rent' - the unearned element in profit arising from publicly-financed land development rather than private investment - has been an important source of capital accumulation, and has perhaps played a major role in the process of capital accumulation.

Finally, prominent if not dominant among those who have been able to tap the 'rent' from favourably-located land, and thus embark on larger scale paddy production, have been those whose position has guaranteed them both an important say in the inter-personal allocation of land, water and other publicly-provided resources and an external source of working capital - government officers.

MAP A.8.1: NOTIONAL TYPICAL IRRIGATION SCHEME LAYOUT



MAP A.8.2: KAUDULLA SCHEME, STAGE I, Showing roads, canals, paddy tracts and main towns



APPENDIX 9: FINANCIAL AND ECONOMIC ESTIMATES OF LAND PREPARATION AND THRESHING COSTS BY ALTERNATIVE METHODS

Position as at:	LAND PREPARATION Financial Rs/acre	LAND PREPARATION Economic Rs/acre	THRESHING Financial Rs/acre	THRESHING Economic Rs/acre
March, 1981[1]				
1. Buffalo pair	175.3	156.8	122.7	109.8
2. 2-wheel tractor	475.3	453.6	-	-
3. 4-wheel tractor	598.5	571.8	239.4	228.7

[1]For detailed assumptions, see the following breakdown of hourly operating costs. Calculations are based on the new 1981 cost of 4wt and 2wt.

HOURLY OPERATING COSTS OF FOUR-WHEEL TRACTOR:

	Financial Rs/hr	Economic Rs/hr[a]
A. 4-wheel tractor		
1. Annual capital charge[b]	40.78	30.92
2. Repairs & maintenance (1.3P)	24.70	24.70
3. Fuel (1.24 gal/hr)[c]	26.04	31.00
4. Lubricants (0.2 x fuel)	5.21	6.20
5. Housing, tax, licensing insurance (0.05p)	9.50	9.50
Sub-total	106.23	102.32
B. Implements (9 tine - tiller & cage wheels)		
1. Annual capital charge[d]	5.90	4.47
2. Repairs & maintenance (1.3P)	3.57	3.57
Sub-total	9.47	8.04
TOTAL COSTS		
1. 4-wheel tractor	106.23	102.32
2. Implements	9.47	8.04
3. Operator payments	4.00	4.00
Total per hour	Rs.119.70	Rs.114.36
Total per acre(at 5 hr acre)[e]	Rs.598.50	Rs.571.80

HOURLY OPERATING COSTS OF TWO-WHEEL TRACTOR

	Financial Rs/hr	Economic Rs/hr
A. 2-wheel tractor		
1. Annual capital charge[b]	9.38	7.90
2. Repairs & maintenance (1.1P)	6.60	6.60
3. Fuel (0.185 gal/hr)[c]	3.88	4.63
4. Lubricants (0.2 x fuel)	0.78	0.93
5. Housing, tax, licensing, insurance (0.05P)	1.50	1.50
Sub-total	22.14	21.56
B. Implements (Rotovator & mud wheels)		
1. Annual capital charge[d]	7.00	5.91
2. Repairs & maintentance (1.1P)	4.92	4.92
Sub-total	11.92	10.83
C. TOTAL OPERATING COSTS		
1. 2-wheel tractor	22.14	21.56
2. Implements	11.92	10.83
3. Operator payments	2.50	2.50
Total per hour	Rs.36.56	Rs.34.89
Total per acre (at 13 hrs/acre)[e]	Rs.475.30	Rs.453.60

NOTES ON ASSUMPTIONS USED IN TRACTOR OPERATING COSTS

(a) Since the 1981 exchange rate (US$=Rs.18) reflected the market value of the Rupee, no shadow rate was then used in project appraisal studies (Central Bank).

(b) The annual capital (A) including the opportunity cost of capital, is assessed according to the formula:

$$A = \frac{P \times r}{1 - \frac{1}{(1+r)^n}}$$

Where (i) P is purchase price of a new tractor (Rs.190,000 for a 47 HP 4wt and Rs.24,000 for a 7 HP 2wt)

(ii) r is rate of interest.
17% (F) is the current commercial bank rate for loans of less than Rs.100,000. In certain project areas the interest rate on tractor loans varies from 12% to 16%.

10% (E) represents the minimum internal rate of return used in some project appraisal studies. Since present discount-rates in UK vary between 5-7% for public sector investment projects, 10% may be considered an optimistic rate for Sri Lanka.

(iii) n is the expected working life of the tractor.

4wt 10 years x 1,000 hrs. p.a.
2wt 5 years x 800 hrs. p.a.

(c) The 1981 pump price of diesel (F) was Rs.21/gal. Since the estimated subsidy is Rs.4/gal. (Ceylon Petroleum Corporation) the shadow price of diesel is Rs.25. Fuel consumption is based on the formula 0.12 litres/horsepower/hour for land preparation (FAO, 1980).

(d) Based on formula in (b) above.

(i) Purchase price of locally manufactured tine tiller and cage wheels is Rs.11,000.
Expected working life (n) is 10 years x 400 hrs. p.a.

(ii) Purchase price of rotovator and mud wheels is Rs.6,000.
Expected working life (n) is 5 years x 268 hrs. p.a.

(e) 4wt: 5 hrs/acre for first and second mudland preparation. This compares with 5.1 hrs/acre for Anuradhapura District and 4.3 hrs/acre for Mannar District recorded by the Department of Agriculture for two mudland (irrigated) preparations during maha 1979/80 (Cost of Cultivation of Agricultural Crops, Division of Agricultural Economics, Farm Management and Statistics, 1979), and 5.3 hrs/acre from the present study (Table 3.2.1).

2wt: 13 hrs/acre for first and second mudland preparation, compared with 8.4 hrs for Polonnaruwa District by Department of Agriculture during maha 1979/80, and 14 hrs/acre from the present study (Table 3.2.1).

In addition:

1. Threshing performance rate for 4wt is 2 hrs/acre, with fuel consumption rate reduced to 0.88 gal/hr.
2. A note of caution - the appended tractor operating costs are based on March, 1981, prices. Since the majority of 4wt in the country are at least 4 years old, the average level of operating costs, strongly affected by the purchase price, are considerably reduced. For instance, the present financial cost of operating a 4wt bought in 1977 for Rs.110,000 and implements for Rs.6,400 is calculated at Rs.88.18 per hour, or Rs.440.90 per acre. By implication, older tractors (up to a certain age), or those with lower purchase prices, earn greater profit margins (hire rates over operating costs). Similarly, the relative importance of variable costs (particularly fuel) increases over time for all tractors, which may render hire charges sensitive to changes in fuel prices. However, this might be partially offset by increased repair and maintenance charges.

DAILY OPERATING COSTS OF BUFFALO PAIR

	Financial Rs/day	Economic Rs/day
A. Buffalo Pair		
1. Annual capital charge[a]	10.18	8.03
2. Adult mortality loss less calf value[c]	2.14	2.14
3. Feed[d]	-2.27	-2.27
4. Veterinary charges[e]	0.00	0.00
Housing, licence, insurance, etc.	0.00	0.00
Sub-total	10.05	7.90
B. Equipment (Yoke, harness and country plough)		
1. Annual capital charge[f]	1.25	0.99
2. Repairs and maintenance[g]	0.66	0.66
Sub-total	1.91	1.65
C. Labour		
1. Herd labour[h]	1.08	0.54
2. Driver/operator charges[i]	15.00	15.00
Sub-total	16.08	15.54
D. TOTAL OPERATING COSTS		
A + B + C (per day)	Rs.28.04	Rs.25.09
Total per acre (at 0.16 acres/day)[j]	Rs.175.30	Rs.156.80

NOTES ON ASSUMPTIONS USED IN BUFFALO OPERATING COSTS

(a) Annual capital charge (A):

$$A = \frac{P \times r}{1 - \frac{1}{(1+r)^n}}$$

Where (i) P = Rs.2,030, the purchase price of a 4 year old buffalo pair (270 Kg.cow, 310 Kg.bull at Rs.3.5/kg.)
(ii) r = (rate of interest) is 17%(F) & 10%(E)
(iii) n = (expected working life of buffalo pair) = 8 years per year = 237 hours (FAO, 1980) or 47.4 days (at 5 hrs/day).
The slaughter value of the buffalo pair at the end of its working life is considered a benefit and is excluded as a cost of operation.

(b) Adult mortality loss is 0.05 P ÷ 47.4 days.

(c) Value of calf production 55% natality, 20% mortality; 70 kg. calf at Rs.3.5/kg. =Rs.107.80.

(d) In most of the Dry Zone buffaloes are freely grazed. Where competition for grazing land exists an economic cost of feed will arise.

(e) Veterinary charges are generally negligible.
(f) Based on (a) above.
P(yoke, harness and country plough) = Rs.250
n = 8 years x 47.4 days.
(g) Repair and maintenance = 1.0P (100%).
(h) Herdsman charges when animals not working = 2 adult + 0.55 calf = 2.55 x Rs.2 x 10 months = Rs.51.
(i) This includes meals and other payments in kind.
(j) Parker, R. N. (1978). Characteristics of Existing Tractor Operations, TIMP, Anuradhapura, gives 0.30 acres/day. However, this appears excessively high when compared with other estimates and with the data is Table 3.2.1 above.
Threshing rates are estimated at 0.14 acres per 5 hour day for a buffalo pair.

APPENDIX 10: REPORTS AND PAPERS TO WHICH THE RESEARCH TEAM HAS CONTRIBUTED

A.10.1 Reports and Papers Arising Directly from Research under the Farm Power Study.

FARRINGTON J & ABESEKERA W.A.T.	(1979)	Issues in Farm Power and Water Use in Sri Lanka, Occasional Publication No.17 ARTI Colombo. pp 46.
FARRINGTON J, ABEYRATNE F RYAN M J & BANDARA S M	(1980)	Reports on Farm Power and Water Use in the Dry Zone of Sri Lanka, Part 1: Study Methodology and some preliminary results, Research Study No 43, ARTI Colombo pp 215.
FARRINGTON J RYAN M J ABEYRATNE F & BANDARA S (Mrs.)	(1981)	Energy in the Small Farm Sector in Sri Lanka Proceedings of Seminar on Energy in Sri Lanka Sri Lanka Association for the Advancement of Science, Colombo January 1980.
FARRINGTON J RYAN M J ABEYRATNE F & BANDARA S (Mrs.)	(1980)	Draught Power for Small Farmers -A Critique of Planning Methodologies in Sri Lanka, Journal of Agrarian Studies, 1,2,13-18, Colombo .
MOORE M P	(1980)	Approaches to Improving Water Management on Large-scale Irrigation Schemes in Sri Lanka Occasional Publication No 22 ARTI Colombo.
MOORE M P	(1980)	Scenarios for Change in Water Management Practises in Sri Lanka, and their Interactions with Farm Power Use, Institute of Development Studies, University of Sussex (unpublished).
MOORE M P	(Forth Coming)	Institutional Adaptiveness and Succession: the case of irrigation in Sri Lanka, Submitted to Journal of Agrarian Studies, Colombo
MOORE M P ABEYRATNE F AMERAKOON R & FARRINGTON J.	(Forth coming)	Space and the Generation of Socio-Economic Inequality in Sri Lanka's Irrigation Schemes (Draft mimeo).
MURRAY-RUST H & MOORE M P	(Forth coming)	Managing Sri Lanka's Irrigation Schemes: The role of Cultivation Meetings, (Draft mimdo.)
RYAN M J ABEYRATNE F & FARRINGTON J	(1980)	Utilisation of Buffaloes for Farm Power in Sri Lanka, Presented at SAREC Workshop on Buffalo Research in Sri Lanka. University of Peradeniya, November.
RYAN M J ABEYRATNE F & FARRINGTON J	(1981)	Animal Draught-The Economics of Revival Occasional Publication No 23 ARTI Colombo pp 62.

FARRINGTON J
ABEYRATNE F (1982) Farm Power in Sri Lanka, Development Study No 22 University of Reading UK

SIRIWEERA W J (1982) Water Resources and Cattle Rearing in Sri Lanka: An Historical Perspective Occaionnal publication No 30 ARTI Colombo pp 53

ABEYRATNE F (1983) Why there is a Need to Revive Buffalo Draught Power in Sri Lanka, Presented at the Seminar on Buffalo Research in Sri Lanka, vetrinary Research Institute, Gannoruwa April 1983.

ABEYRATNE F &
FARRINGTON J (Forth coming) Water Availability and the Access to Farm Inputs in Major Irrigation Schemes in Sri-Lanka - with particular reference to draught Power: In 1982 Year Book for Sri Lanka water Management Research - Proceedings of work-shop on Water Management in Sri Lanka - Jan. 1982, ARTI Colombo.

W.M. SIRISENA (Draft Mimeo) Sociological Analysis of the Farm Power Study.

A.10.2 Publications Arising from Research in which the Farm Power Study Team has Participated in a Minor Capacity

CROOKS G R & RANBANDA H A	(1981)	The Economics of Seasonal Labour Migration in Sri Lanka, Research Study Series, ARTI Colombo.
FARRINGTON J & FIELDSON R S	(1981)	The Assessment of Farmers' Behaviour in the Design of Irrigation Settlement: An analysis of Settlement Project in Sri Lanka, Quarterly Journal of International Agriculture 20,3 293-303 Berlin
FARRINGTON J & FIELDSON R S	(Forth-Coming)	Designing Irrigation Settlement: the interface between planner and farmer, Submitted to Sri Lanka Journal of Social Sciences, Colombo.
FIELDSON R S & FARRINGTON J	(1980)	Labour Supply for Small Farm Development in the Dry Zone: Recent Patterns and Future Prospects, Paper presented at Seminar on: Research Development and Rural Workers 25.4.80 ARTI Colombo.
FIELDSON R S	(1981)	Farm Labour Input in the Dry Zone of Sri Lanka, Occasional Publication No 24 ARTI Colombo, pp 110
MOORE M P	(1980)	The Management of Irrigation Systems in Sri Lanka: A Study in Practical Sociology, Sri Lanka Journal of Social Sciences 2,2 Colombo
RANATUNGA A S FARRINGTON J & ABEYSEKERA W A T	(1981)	Some Issues Confronting the Rehabilitation of Major Irrigation Schemes, Research Study No 44 ARTI Colombo, pp 50
MOORE M P & FARRINGTON J	(Forth coming)	Capital and Peasant Farming in Sri Lanka, submitted to Journal of Agrarian Studies, Colombo.

APPENDIX 11: PAPERS PRESENTED AT THE REGIONAL SEMINAR ON FARM POWER, ARTI, COLOMBO, 25th-29th OCTOBER, 1982

1. Keynote Address:

Bart Duff & P. Moran Kaiser	The Mechanisation of Small Rice Farms in Asia

2. Policies and Institutions in Sri Lanka

Frederick Abeyratne	Changing Patterns of Farm Technology in Sri Lanka
Ben H. Farmer	The Origins of Agricultural Colonisation in the Dry Zone of Sri Lanka
John Farrington	Options in Irrigation System Management and their Implications for Farm Technology in Sri Lanka.
John Farrington & Frederick Abeyratne	The Impact of Small Farm Mechanisation in Sri Lanka.
Michael Lipton	Farm Technology, Urban Institutions and the Rural Poorest: some lessons of tractorisation in Sri Lanka.
Lakshman Wickrema-singhe, C. M. Wijeyaratne & Sena Ganewatte	The Institutional Framework of Irrigation and Cropping on Major Colonisation Schemes

3. Future Perspectives in Sri Lanka

B. S. Pathak	The Prospects of Alternative Energy Systems in the Production Agriculture of India and Sri Lanka.
Henk Perdok	Urea-ensiled Paddy Straw and its Potential as Draught Animal Feed.
M. George Pillainayagam	Research into Farm Power and Equipment in Sri Lanka.
Ray Wijewardena	Why Farm Power? Performance and Prospects of No-Till farming.

4. Experience with Farm Power Policies in the Region

Gerard J. Gill	Tractorisation and Rural Employment in Bangladesh.
Supachat Sukharomane	The Impact of Farm Power Strategy in Thailand.
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