Fred

FARM POWER AND WATER USE IN THE DRY ZONE

PART-1

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Research Study No. 43

OCTOBER 1980

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

Study Methodology And Some Preliminary Results

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A joint ARTI/Reading University Project

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FOREWORD

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

The field work for the study has now been completed but the issue of the final report with a complete analysis of the data collected is not scheduled until late 1981. In the meantime, this report giving the preliminary results of the survey is being issued as it is felt that the questions raised by the authors require early attention to avoid any unnecessary and wasteful investments in this area. It contains information and arguments of direct relevance to policy questions of whether further investment is needed in farm power and, if so, in what form.

Mr.J.Farrington, Colombo Plan Advisor, was mainly responsible for the designing of the study and the preparation for field work. Mr.W .A . T Abeysekera, Research and Training Officer, functioned as the Joint Co-ordinator of the study team in the initial stages, later he was replaced by Mr.F.Abeyratne, Research and Training Officer . The other members of the team were Mr.M.Ryan, a visiting researcher and Mrs.S. Bandara, Research & Training Officer. They were all responsible for the supervision of field work and data analysis.

The sociological aspects of the study were the responsibility of Mr.Ishak Lebbe, Research and Training Officer and Dr.W.M.Sirisena of the Peradeniya University. Mr.Ishak Lebbe was responsible for the sociological research at Uda Walawe and Dr.W.M.Sirisena was responsible for the work at Padaviya and Kaudulla. Dr. Sirisena contributed largely to the analysis of quantative sociological data and the sociological section of this report. Water Management investigations were the responsibility of Mr.M.P.Moore of the Institute of Development Studies, Sussex, who functioned as a short-term consultant in 1980. Some of his findings are given in another ARTI publication entitled "Approaches to Improving Water Management on a large scale irrigation schemes in Sri Lanka." Under this project there was also an earlier publication called "Issues in Farm Power and Water Use." It is hoped that all these publications will help to understand the real situation regarding availability and utilization of farm power in the country with a view to evolve a more efficient system for its use.

T B SUBASINGHE
DIRECTOR

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PREFACE AND ACKNOWLEDGEMENTS

In the initial proposal, it was intended that this first report on the field work of the Farm Power and Water Use Study should be chiefly concerned with issues of study methodology. At an early stage in the field work, however, it became apparent that there was a need to publish some of the main findings, even if reservations regarding their preliminary nature had to be made. It is hoped that by now doing so, a useful contribution can be made to the discussion of future farm power and energy resources, initiated, for instance, in a recent FAO planning document and in the Sri Lanka Association for the Advancement of Science's 1980 Energy Seminar. This report thus goes beyond its initially conceived scope.

The study team have 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, as well as from informal discussion with colleagues at ARTI. Additionally, the constant involvement of the Department of Agricultural Economics at Reading University, made effective particularly through the consultancy visits of H Mettrick, and the interest of the Institute of Development Studies at the University of Sussex have been of lasting benefit to the study. The contributions received from these many sources are gratefully acknowledged.

The researchers are heavily indebted to the team of investigators, who have conscientiously carried out a complex programme of data collection in the face of many practical difficulties. To the farmers and owners of farm power, who freely gave their time to provide information, we own a similar debt.

Finally a word of thanks to Miss. Anne Fernando who took lot of trouble to do a fine job in preparing the script for publication.

The authors alone are responsible for any remaining errors of fact or interpretation.

J.F.

F.A.

OCTOBER, 1980.

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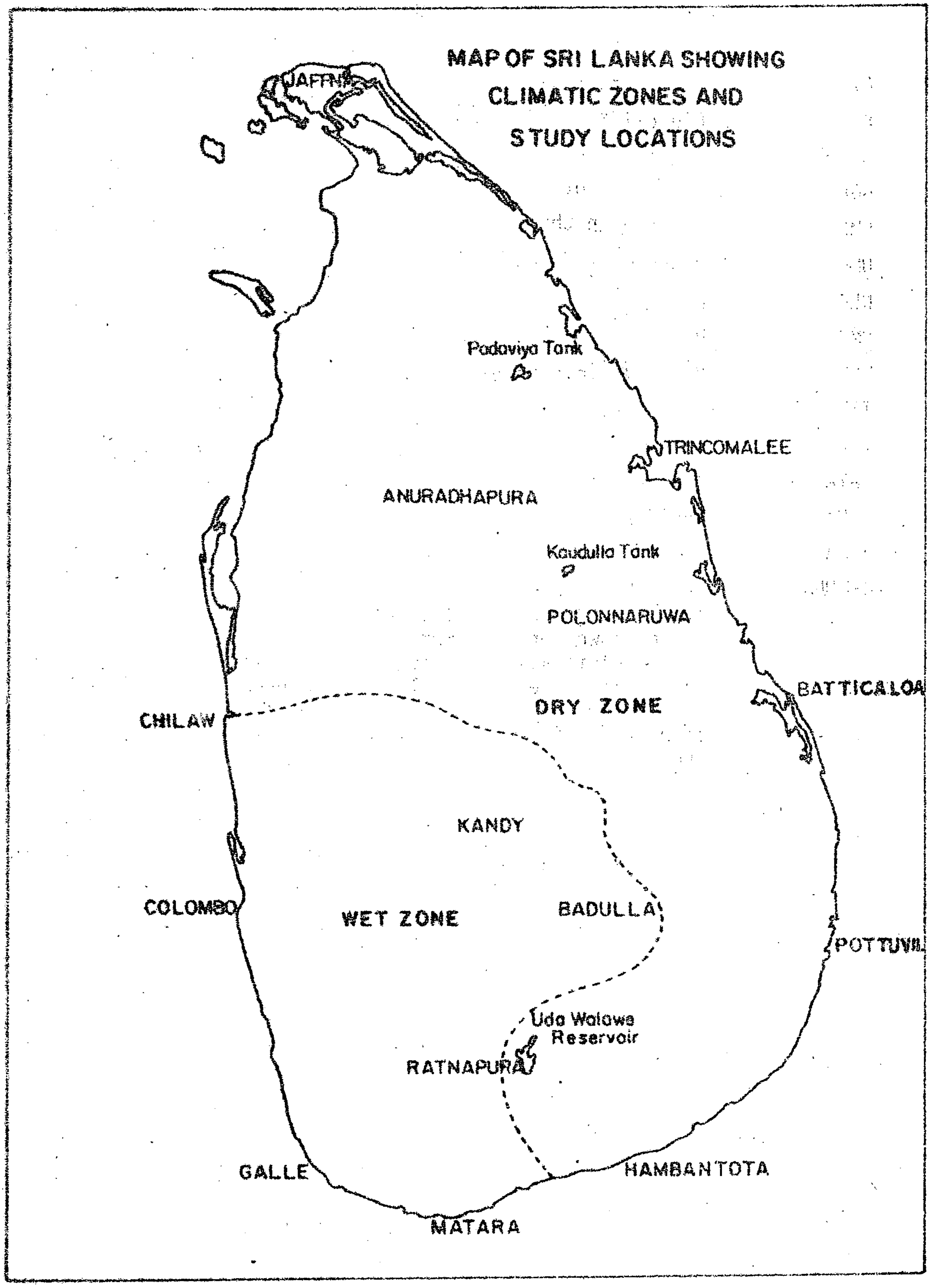
GLOSSARY

AI	Agriculture Instructor
KVS	Field-level Extension Worker
CO	Cultivation Officer
BOP	Blocking-out Plan
LMC	Lower Main Channel
UMC	Upper Main Channel
NLB	National Livestock Board
RMV	Registrar of Motor Vehicles
RVDB	River Valleys Development Board
TIMP	Tank Irrigation Modernisation Project ("5 Tanks").
LIYADDE	The smallest bunded unit within an irrigated field
YAYA	An irrigated tract of land, comprising several farms
MAHA	The(North-East)monsoon - October - April
YALA	The lesser(South-West) monsoon - May - September
BETHMA	From the Sinhala "bethima" (= to share or divide) A system of (usually Yala) cultivation in which allottees 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.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GALLE
HAMBANTOTA
MATARA

SUMMARY

The basic study objectives are described, and the selection of methodologies appropriate to their achievement discussed. Particular attention is given to the design of field investigations, including sampling methodologies, the recruitment and training of field investigators and the design of survey schedules.

The observed power population densities at the study locations are analysed. Some variation in density (per 1000 acres of paddy) is evident among locations, and a consistent tendency for tractor populations to decline markedly in density towards the tail-ends of all three locations emerges. This is not the case with buffalo. The implications of such variations in power density for the availability of power-time on the hire-market are discussed.

Little divergence of tractor ownership patterns from the norm of one per owner was observed. For buffaloes, the average herd size per owner varied widely among, but not greatly within, study locations. The herd sizes were largest at Uda Walawe and concentrated among few owners, and the lowest at Kaudulla with widespread ownership. Correspondingly different management and use-patterns of buffalo were observed: at Kaudulla they were generally tethered in the home stead allotment and stall-fed, and were used with ploughs; at Uda Walawe they were freely grazed and used predominantly for trampling ("mudding") the soil. It is clear that the Kaudulla system has much better prospects of success under the large, intensively farmed areas now being opened up under the Mahaweli Scheme, and subsequent reports by this study will attempt to gauge its efficiency by comparison with open grazing.

Preliminary results are presented from an analysis of the use-hours of the three farm power types (4-wheel tractors, 2-wheel tractors and buffaloes) for the early part of the Maha season (26/8/79 - 19/1/80). The overwhelming impression is one of very low use intensity, a weekly average of some 10 - 15 hours/tractor (for 4 w.t. and 2 w.t.) being typical. This rises to some 20-25 hours/week in a brief peak period. Variations, which

can generally be accounted for in terms of individual locational characteristics, are found in the proportions of work done in agricultural and non-agricultural operations , and between work done for the owner himself and on hire. Agricultural work accounts for all of buffalo time and the bulk of tractor time, with the exception of Uda Walawe, a location with developed commercial infrastructure which has a high transport requirement. Insofar as the same pattern of commercialisation is likely to emerge also in other settlement areas, this trend gives cause for concern. Owners who derived the bulk of their income from non-farming activities (i.e "businessmen") were observed to obtain slightly higher use from tractors, with a bias towards non-agricultural operations. For all owners, the proportion of tractor time hired out varies both by location and by power type. For 4 w.t. it generally exceeds two-thirds, but for 2 w.t. varies between one quarter and two-thirds. Where buffalo herds are larger (Uda Walawe), 95% of time is hired out, but less than 15% where they are small (Kaudulla).

The finding of low use-intensity raises important policy questions: would it be feasible and more economically worthwhile to raise the use-level of the existing tractor stock instead of continuing to import additional tractors at existing low use-levels?. Is the national tractor stock currently so high that in many locations there would simply not be enough work available to permit use-levels to be raised substantially? If it is feasible, the raising of use-levels appears the more economically desirable course, yet a brief discussion of the theory of capital acquisition and use and its application to tractors in Sri Lanka, highlights the numerous obstacles to such a course of action. It is suggested that at the national level there is an abundance of aid funds, frequently tied, for tractor purchase, with lack of alternative investment opportunities for such funds, and therefore the absence of pressure to obtain rapid returns to tractor investments. Similar forces operate at the individual owner level. Lack of alternative investment opportunities and prestige considerations are thus suggested as a primary cause of low use intensities. Other causes (poor repair facilities, non-availability of spares, fuel, etc.) more conventionally acknowledged, are also put forward. Analysis of future data will permit some further testing of these suggestions.

A section on water management suggests that, for reasons which differ little among locations, there is a high degree of "automaticity" in water flows, and that the scope for positive intervention by scheme management, particularly at D-channel and field channel levels, and in the lower reaches of main channels, is severely constrained for both physical and institutional reasons. This finding has strong implications for the level of sophistication of potential solutions to the perceived farm power/water use problems that is likely to be implementable under current organisational and infrastructural conditions. One such possibility involves the organised staggering of water issues within locations to permit both water saving and greater power use-efficiency. Another requires the more efficient organisation of decision-taking in matters affecting agriculture and water at the tank level.

In detailed Appendices, the characteristics of the study locations are described, as are those of the "owners" samples. The data collection schedules are presented. Analysis of the size and distribution of the national farm power stock suggests tentatively that there is unlikely to be a national farm power deficit. Further Appendices discuss the interaction between use-intensity and hire-charges, and list the published and unpublished work in which the members of study team have been involved.

* * * *

CHAPTER 1

INTRODUCTION

This study is a collaborative research project between the Agrarian Research and Training Institute (ARTI), Colombo, and the University of Reading. It is funded by the Government of Sri Lanka and by a grant from the Economic and Social Committee on Overseas Research (ESCOR) of the Overseas Development Administration (ODA).

The study's underlying rationale has already been discussed in detail in the project submission and summarised in an Appendix to Farrington and Abeysekera (1979), which is reproduced as Appendix I here. The fundamental concern is with the efficient combined use of those farm inputs which are substitutable to some degree. A particular focus of attention is the use of water, since the abundance of land potentially available for irrigation in the Dry Zone gives this factor a high opportunity cost. Several inputs or technologies can to various extents substitute for water, including weed control practices, alternative lengths of growing season, transplanting versus broadcasting options, and so on. The study is concerned with all of these, but the most potentially important area of substitutability is between water and farm power in land preparation, and this will form the focus of the study.

Farm power use-efficiency is thought by many standards to be low: small plot sizes involve a high proportion of "turning time", implements are on the whole crude, even when used with sophisticated power sources; animal power is frequently used without any implements at all, the simple trampling action, although time-consuming, performing adequate churning of the soil; hire-market inefficiencies are thought to exist- tractors and buffalo have been observed standing idle whilst farmers within the same locality have had to delay land preparation for lack of power. Above all, at major irrigation schemes, much unorganised staggering of cultivation takes place, with the result that crop growing periods fall outside the monsoon rains, placing higher demands on stored reserves of water, demands which are exacerbated by extended water issues to cater for those farmers at the end of the staggering line.

The mix of research methodologies necessary to tackle problems such as these is complex. It will comprise both systematic and detailed field investigations, and the review of results from experimental work.

1.1. FIELD INVESTIGATIONS

Existing information on the use - pattern of farm power in land preparation is fragmentary. No firm information exists on even such straight forward and critical parameters 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 patterns 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.

1.2. ANALYSIS OF EXPERIMENTAL WORK

The full scope for improvement in use-ratios between water and substitutable inputs cannot be explored on the basis of field surveys alone. In addition it is necessary to examine the economic potential of technologies still at the experimental stage, without neglecting to allow for the specific constraints and requirements of such technologies. In this connection the study will maintain close contact with a number of research organisations, including :

1. Maha Illupalama Agricultural Research Station (for experimental work on farm power and general practices; cropping systems research on minor tank irrigation).

2. Tank Irrigation Modernization Project (research on farm power and related technologies and on water use practices).

3. Ministry of Mahaweli Development (esp. Systems H irrigation trials initiated by Huntings Technical Services Ltd.).

4. Irrigation Department and Hydraulics Research Station/ Institute of Hydrology (UK) (esp. in relation to water balance studies at Kaudulla).

5. ICRISAT and IRRI, two international organisations pursuing a broad programme of research at the regional level into many issues of farm power, water use and general agronomy of relevance to the study.

A brief statemnent of how data generated by these institutions are expected to contribute to the study objectives is contained in Appendix III. The data collected from the field and from on-going experimental work conducted by the above institutions will be synthesised into a number of resource-management scenarios with implications for both local and national - level planning. At this stage in the research it is impossible to predict precisely what form these might take; the underlying philosopy will be one of starting from observed use-levels of currently used parameter sets, and comparing them with what is necessary to achieve local and national objectives, both with and without the constraints imposed by current administrative systems and political choices. For instance, power and water-use efficiencies will initially be taken as given, the attempt then being made to assess both the profitability (in private and social terms) and the feasibility of achieving greater efficiencies in use-levels of the main input parameters, both individually and in combination. It may, in this way, be possible to start a path of increasing refinement in input use applicable to a spectrum of initial resource-endowment conditions. The implications of such models for national-level planning (on e.g. import scale and composition of farm power; energy policies; animal production programmes, etc.) will be clearly emphasised. The study will be particularly concerned with the limits to economic, political and administrative feasibility of change in agriculture. It will not be concerned with economic optima, but with the trade-off between increasing levels of (sub-optimal) profitability and increasing political and administrative constraints. The intention is to make practicable contributions to economic development, not to postulate unattainable economic optima.

The remainder of this first report produced by the study gives an account of work done between May 1979 and April 1980. It is divided into three main components:

(i) A comprehensive description of why and how field investigations were set up.

(ii) Presentation of preliminary results from analysis of field data for part of Maha season 1979-80.

(iii) A series of appendices in which the individual research interests of the study team and, more widely, of outside organisations, are discussed and related to the underlying themes of the study as a whole.

CHAPTER 2

FIELD INVESTIGATIONS

2.1. SELECTION OF STUDY LOCATIONS:

The field data collection programme for this study is designed to provide data for a wide range of values of key variables in farm power and water use. The analysis of this data will 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 can 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) Contain both newly-settled and traditional (purana) populations to permit study of the varying impact on power use of different social structures.

(v) Have both state-owned and private institutional arrangements for the hiring of power, access to credit, etc.

(vi) Display a variety of institutional arrangements for the control of irrigation water supplies.

(vii) Display a variety of holding and plot sizes, within which should fall those planned for wider Dry Zone development (esp. the Mahaweli Project).

(viii) 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

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*These criteria correspond closely with those specified in the study proposal.

net benefits of using water in alternative ways can be made.

To assist in identifying specific study locations, a listing was made of Dry Zone major irrigation schemes. Several criteria have previously been used to distinguish 'major' from 'minor' irrigation. A threshold of 200 acres of command area is commonly used in the presentation of government statistics on paddy production. Another criterion of 2000 acres of command area has been used by Parker (1979). These criteria do not seem appropriate to the issues currently under discussion. In particular, one objective of the study is to examine variations in farm power and water availability and use-patterns within schemes, and if adequate sample sizes for each of the three types of power are to be obtained at both the upper (where water is generally abundant) and lower (where it is sometimes scarce) ends of command areas to permit rigorous statistical testing for such differences, the command area criterion for distinguishing major from minor irrigation must be higher than the examples quoted above. The selection of a cut-off acreage is ultimately arbitrary: on the assumption that 4-wheel tractors would be the least densely distributed form of power, and that as preliminary observations suggested, their population would probably not exceed 10 per 1000 acres of command area in any Dry Zone irrigation scheme, a cut-off acreage of 7500 was selected for the purposes of the study. According to an authoritative source (Arumugam, S.: Water Resources of Ceylon, Colombo, 1969), this leaves a total of 14 major irrigation systems in the Dry Zone from which to choose. These are presented in the following table.

Table 1. DRY ZONE MAJOR IRRIGATION WORKS OF GREATER THAN 7500 ACRES COMMAND AREA

Scheme	District	Water Storage Capacity (acre-feet)	Approx. Command Area (acres)	Catchment Area (Sq.miles)[1]
Allai	Trincomalee	-[2]	10000	-
Gal Oya	Amparai/ Batticaloa	770000	120000[3]	384
Giants Tank	Mannar	26600	19500[3]	-
Huruluwewa	Anuradhapura	55000	8000	77
Iranaimadukulam	Vavuniya	82000	19000[4]	277
Kalawewa	Anuradhapura	72700	12700[4]	-
Kantalai	Trincomalee	110000	20500[5]	-
Kaudulla	Polonnaruwa	104000	12000[5]	-
Minneriya	Polonnaruwa	110000	15000[5]	-
Padaviya	Anuradhapura	72500	13000	106
Parakrama Samudra	Polonnaruwa	98000	18200	-
Rajangana	Anuradhapura	81500	19000	-
Rugam	Batticaloa	16120	7814	35
Uda Walawe	Ratnapura/ Moneragala/ Hambantota	203000	35000	454

Source: Arumugam, S. (1969) unless otherwise stated.

Notes:

1. Catchment areas are given only for those tanks which are not linked by canal or drainage systems to other major water control works.
2. This tank has become relatively insignificant with the assured provision of diverted water from the Mahaweli Ganga.
3. Includes areas supplied by diversions associated with the Giants Tank complex.
4. This acreage is taken from Arumugam, and is prior to Mahaweli System H development
5. These figures are not taken from Arumugam but are as supplied by the Irrigation Department.

Two further criteria were imposed in making a final selection of study locations from these 14 potential sites.

First, 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).

Secondly, 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 5 tanks under the Tank Irrigation Modernization Project, based at Anuradhapura, are strong contenders for study. These two criteria, in addition to (i) - (viii) 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 survey sites would be necessary to meet the stated objectives, supplemented by data currently being collected by other studies in other areas of major irrigation, and in minor irrigation.

1) SELECTION OF A CANAL - LINKED STUDY LOCATION:

The list of the 14 major irrigation works given above suggests two possible areas from which a canal - linked locatinn might be selected.

One is the Polonnaruwa complex (including Minneriya, Parakrama Samudra, Kantalai and Kaudulla);the others,the newly developed lands under Mahaweli Ganga System H, including Kalawewa, with Rajangana and Rajangana and Giants Tank receiving drainage water.

The former area was thought more appropriate for two reasons; it is an area in which current agricultural settlement started some 30 years ago, and thus may present a degree of stability and equilibrium among the major agro-economic variables which is unlikely to be found in an area such as System H, where less than half of the planned settlement has so far taken place. In particular, certain types of farm power are poorly represented there. Secondly, the Sri Lanka/IDRC Research into cropping systems, based at Maha Illupallama Research Station, has already undertaken data collection in System H on farm input use levels, cropping practices, land use and outputs. As specified in the research proposal for the present study, it is intended to conduct specific studies on the use of farm power among the sample selected for the cropping systems work, in order that duplication of data collection might be avoided.

Thus, it was decided to select an irrigation scheme from the four listed above in the Polonnaruwa complex. Kaudulla was found to be the most suitable for several reasons, the more important of which are:

It displays holding sizes corresponding more closely with those proposed for many parts of Mahaweli than does, for instance, Minneriya (2 or 3 acres of paddy and 1 of upland at Kaudulla, as against 5 of paddy and 3 of upland in many parts of Minneriya); second, a major study on water balances is in progress at Kaudulla conducted jointly by the Irrigation Department and the Hydraulics Research Station/Institute of Hydrology(UK). It is hoped that the water demand and water balance models developed in this work will permit accurate determination of inter alia the implications at tank level and over time of any water savings at specific locations within the command area. It was therefore thought opportune to study there in depth farmers' behaviour in those technologies (especially power) which have a bearing on water use in the field and ultimately at tank level.

The one disadvantage of Kaudulla in terms of our above criteria is that it is at the end of the canal - linked system, and so any fear among farmers that water saved will simply be passed on to the next tank will not be observable. On the other hand Kaudulla's position at the end of the system is expected to raise other issues of interest. The balance of evidence was thought to lie in favour of selecting Kaudulla.

2) SELECTION OF A SINGLE-CATCHMENT LOCATION:

Our listing in Table 1 above presents 6 possible study locations that are not linked by canal or drainage systems with other major works. Of these, it was decided that Padaviya was the most appropriate. A major reason for its selection was that it is one of the 5 tanks scheduled for improvements to irrigation and other infrastructure under the Tank Irrigation Modernization Project. This Project will also provide credit assistance for the purchase by farmers of additional farm power, especially with a view to reducing and synchronising the period necessary for land preparation. Since the implications of this project are important both in their own right and as a model for Mahaweli development, it was thought most appropriate that the study should attempt, by its own data collection, to illuminate both the prescribed issues of general concern in farm power and water use, and the more specific issues arising from implementation of the modernization programme. (cf Appendix III).

3) SELECTION OF A FURTHER STUDY LOCATION:

Since the selection of the two above locations had satisfied many of the criteria relating to catchment and the composition of farm power, it was decided to select a third location with specific reference to water use criteria. One location, Uda Walawe, recommended itself for several reasons. On the one hand, it was known to have a high seasonal water issue; on the other there exists a severe and persistent shortage of water at the lower end of the system. Additionally, the attempt had been made - albeit largely unsuccessfully - to introduce non-paddy crops, especially cotton, for irrigated cultivation. It was thus hoped to learn there something of the issues relating to power and water use in the production of these crops, particularly since much of the success of Mahaweli development will depend on successful diversification into irrigated and settled rainfed production of crops other than paddy.

2.2 Sample Selection Within Study Locations

1) Farmers: The most fundamental consideration in selecting farmer 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 asweddumuzed land (i.e. along distributary and field channels). These observations are confirmed in a host of writings on the subject, but particularly by Chambers (1975).

Numerous examples can be given of variations in water availability. At Padaviya, for instance, tracts located at the upper and middle portions of the command area (tracts 1 - 10) contain some 5% greater area of paddy land than was originally envisaged in the Blocking-out Plan, the surplus being attributable to encroachment of cultivation onto reservations of various types, whilst in the tail end tracts (11-13) only 62% of the area laid out for cultivation cna be irrigated in a typical Maha season (Table 11.3)

Again, at Uda Walawe, water shortages have compelled the abandoning of plans to irrigate tracts 20 and 21 at the tail end of the Right Bank main channel, and tract 19 is irrigable only in part. There, the reduced availability of water on a tract-wise basis is not so easily detected because of varying ratios of planned to actual cultivation of paddy and non-paddy crops. In general, where adequate water is available, farmers have preferred to grow paddy instead of subsidiary crops and many lands designated for subsidiary crops to which adequate water for paddy cultivation cannot be supplied have been left fallow. This is clearly evident in Table II.1, the tracts with more than adequate water supply (2-14 and Chandrikawewa, but excluding Chandrikawewa Tract 6, where the channel was partially out of commission) having cultivated 27% more paddy land than envisaged, but only 22% of the planned subsidiary crops acreage. In the tail-end tracts (15-9) 24% more paddy land was cultivated than had been planned for, but the remaining irrigable land, designated initially for subsidiary crops (3377 acres, against 1988 acres of paddy) was left uncultivated, except for a hundred or so acres of irrigated cotton and chillies and some 600 acres of rainfed crops. At Kaudulla, since diverted water from the Mahaweli Ganga became available in 1976, cropping problems attributable to water shortages have been rare. In Yala 1979, however, many instances of failure of the paddy crop were observed in Stage II (served from the upper sluice) and several in Tract 8 at the tail end of the Stage I channel system.

Constraints imposed on cropping activities by water shortages along distributary and field channels are less easily quantified, but nonetheless important. During Yala 1979, for instance, several observations were made of paddy failure, particularly at the tail ends of distributary channels in Kaudulla (see above). At Padaviya, water distribution problems in Maha are known to exist at the tail end of one very long tract (Tract 6, Lower Main Channel - over 2000 acres of asweddumized land), and this part of the tract is not normally irrigated in Yala, in spite of the fact that it is nearer to the headworks than the upper ends of some other tracts which do receive Yala water. At Uda Walawe, the lower end of Tract 4 does not always receive water at the necessary frequency, which is reflected in low cropping performance (Table II.1) and parts of the distributary systems of Tracts 16, 18 and 19 do not convey adequate water for irrigated cropping of any kind, and have largely been abandoned.

Apart from access to irrigation water, the availability of farm power, at least as far as it is reflected in ownership data, is also highly skewed towards the middle and upper reaches of command areas (Table 12-15). It is, of course, possible that an efficient market for the hiring of farm power would permit rapid allocation of use-opportunities to areas where ownership concentration is low, but numerous observations suggest that it would be unwise to attribute a high degree of efficiency to power hire-markets, and so the ownership distributions presented in Tables 12-15 must to some degree also reflect real biases in access opportunities to the disadvantage of those at the lower ends of the command areas.

These criteria of resource availability governed the patterns of selection of sub-locations for study within the command areas.

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 locations 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 location. In such circumstances, it was though advisable to select a sub-location for farm level sampling. The underlying reasons for this are complex and revolve around the layout of irrigation infrastruxture 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 2000 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-representarion 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.

For these reasons, sub-locations were selected within tracts at all sites.

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 in-tract (i.e. across scheme) water constraints.

At the lower end of the Right Bank, field observations suggested that cropping patterns and performance varies 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 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.

KAUDULLA

A brief description is given in 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 5 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 (1512 acres of a total BOP paddy acreage of 4609 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.

A further sample of 20 farmers at Kaudulla was taken outside the scheme boundaries. Some 1000 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 5 farmers with land alienated under the 1948 Act at Waddigawewa and 15 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. As Table 10(a) shows, 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 under the LMC at 2097 acres of a total BOP area of 8646 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). 20 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 headworks (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 as 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.

2) 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 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 disproportinnately 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:

(i) the extent to which several power sources, of the same or different types, were concentrated into the hands of a single owner;

(ii) 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 farmer 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
   (

   (Tract 2
3. Padaviya (Padaviya Town
   (

   (Tracts 7-9
   (Tract E
   (

   (Tracts 10-12

   (Pulmoddai

Three aspects of this listing require further explanation :

(i) At Uda Walawe, the fact that very few 4-wheel - tractors 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.

(ii) At Kaudulla, insufficient numbers of 4-wheel tractors 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 (Table 11).

(iii) At Padaviya, preliminary investigations of power ownership in areas adjacent to the scheme revealed a high density of 4-wheel tractors at Pulmoddai. A list prepared by the relevant cultivation officer revealed a total of 26 tractors owned there. Since the population of 4-wheel tractors at Padaviya itself was known already to be high relative to the two other study locations (see discussion of populations below), 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 2 SPATIAL CLUSTERING IN SAMPLE SELECTION

		Initial Sampling Frame[1]	Reduced Sampling Frame[1]	% Frame retained (reduced / initial X 100)
Uda Walawe	4 W.T.	57	23	40.4
	2 W.T.	339	122	36.0
	Buffalo	198	59	29.8
Kaudulla	4 W.T.	18	14	77.8
	2 W.T.	49	34	69.4
	Buffalo	1094	498	45.5
Padaviya	4 W.T.	150	62	41.3
	2 W.T.	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 : 4-wheel tractor; 2-wheel tractor; 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. Nonetheless, It was thought necessary to supplement the 4-wheel tractor 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 are discussed below. The characteristics of owners samples are presented fully in Appendix IV.

(i) Multiple Ownership*

Stratification to obtain adequate coverage of the first of the above two sub-sets was easily introduced, since the complete listings of power ownership obtained permitted clssification by number and type of power owned. The degree of greater than average representation given to this sub-set can be observed in the following table. Briefly, it is the ownership of multiple mechanised power units, or of mechanised/animal combinations which is of interest here, since the ownership of more than one unit of animal power is commonplace. Thus, the population and sample data on ownership of non-traditional power can be broken down as follows:

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* Full details of multiple ownership in populations and samples are given in Appendix IV.

TABLE 3 MULTIPLE OWNERSHIP IN POPULATION AND SAMPLES

	Uda Walawe[1]			Kaudulla[2]			Padaviya[3]		
	Population Nos.	Sample Nos.	% sample	Population Nos.	Sample Nos.	% sample	Population Nos.	Sample Nos.	% sample
Owning one 4 w.t. or 2 w.t only	126	34	27.0	28	21	75.0	101	34	33.7
Owning combinations of 4 w.t. / 2 w.t./ buffalo or more than 1 4 w.t or 2 w.t.	19	13	68.4	20	13	65.0	29	12	41.4

1. Excluding samples and populations from Tracts 10 & 11A.
2. Excluding samples and populations from Minneriya.
3. Excluding samples and populations from Pulmoddai.

Where population sizes have permitted, the tendency has thus been towards proportionally heavier sampling of the 'multiple owners'. Only in the case of Kaudulla, where selection was constrained by the small absolute numbers of owners, was this not the case.

(ii) Stratification by main occupation

The procedure necessary to give adequate representation to this sub-set was more complex.

The populations at all 3 study locations were divided into allottees and non-allottees, the latter including a large component of small traders and businessmen. Since data on the composition of tractor owners' income could not be obtained at the time of sample selection, the allottee/non-allottee distinction was the only one that guaranteed some representation in the samples of those owners for whom non-farming activities contributed a large proportion of income. At the same time, however, it is likely that some (but at the time of sampling, unspecified) allottees could have substantial non-farming income. The allottee/non-allottee distinction should therefore be observed in two aspects:

(a) It is important in its own right in that it may illustrate aspects of power use which differ according to land tenyrial status vis a vis the scheme under observation.

(b) It also serves as a criterion (albeit an imperfect one) to permit ex-ante stratification of the populations between, on the one hand, those earning a high proportion of income from farming and, on the other, those earning a high proportion from non-farming activities.

Data will eventually be collected on the relative contribution to sample owners' incomes of various economic activities, and will thus permit ex-post grouping of the samples according to predominant activity. For sample selection purposes, the allottee/non-allottee distinction was the best available means of ensuring adequate representation in the sample of those owners with predominantly non-farming income sources.

The sampling proportions between allottees and non-allottees are indicated in the following table.

TABLE 4 ALLOTTEE/NON-ALLOTTEE DISTINCTIONS IN POPULATIONS AND SAMPLES

	Uda Walawe			Kaudulla			Padaviya		
	Population Nos.	Sample Nos.	% sample	Population Nos.	Sample Nos.	% sample	Population Nos.	Sample Nos.	% sample
Allottees	111	22	19.8	48'	34	70.8	108	37	34.3
Non-allottees	34	25	73.5	0	0	0	22	9	40.9

Note: The same notes apply as for Table 3 above. Buffalo owners have to be excluded because precise details of non-allottee buffalo owner populations are not available.

Again, with the exception of Kaudulla, where all owners were allottees, the sampling of non-allottees is proportionally higher than that of allottees, although in absolute numbers the allottees are predominant, particularly when buffalo ownership is included (Table 4)

2.3. Field Investigators

1) SELECTION

Discussions with Research Officers at ARTI who had accumulated substantial experience of field data collection suggested that with the envisaged work load it would be appropriate to allocate a maximum sample of 20 farmers or owners to each investigator. This was intended to permit data collection for the majority of schedules on a frequent-visit basis (2-3 visits per sample member per week).

It was agreed during formulation of the study proposals that investigators would be recruited under ARTI terms and conditions on a casual basis for the period of field data collection. The only exception to this procedure lay in the allocation to the study of 3 investigators from the permanent cadre of ARTI. One of these was based at each study location with the intention that he should provide a degree of technical advice to casual investigators and act as administrative link between investigators and research staff. In view of these additional duties, the sample allocated to permanent investigators was only 50% of that given to casuals. In all cases it was thought that the broader experience of permanent investigators made it appropriate to allocate to them the potentially more complex exercise of eliciting information from owners.
The allocation of investigators is summarised below:

TABLE 5 ALLOCATION OF DUTIES TO INVESTIGATORS

Location	Investigator type	Total nominal sample size	Sample type
Uda Walawe	4 X Casual	80	Farmers
	3 X Casual	60	Owners
	1 X Permanent	10	Owners
Kaudulla	4 X Casual	80	Farmers
	3 X Casual	60	Owners
	1 X Permanent	10	Owners
Padaviya	4 X Casual	80	Farmers
	4 X Casual	75	Owners
	1 X Permanent	10	Owners
ARTI Office	2 X Casual	--	) 240 Farmers
Total	27	465	) 225 Owners

The recruitment of casual investigators followed conventional ARTI practices, the first batch of candidates under the Job Bank Scheme being interviewed in July 1979.

Owing to poor response among candidates, their generally indifferent quality and a number of administrative shortcomings, several selection sessions had to be held before the full complement of posts could be filled. Fortunately, this resulted in only marginal delays in commencing the field work. Further selections were necessitated by the high initial departure rate of those recruited; some 50% left in the first 6 months of field work. Initially only candidates with degrees were considered. Later it became apparent that candidates with "A"- Level were likely to show stronger commitment to the work with no reduction in aptitude. This, combined with a general increased demand in the graduate job market, led to the adoption of 2 passes at "A" -level as the criterion for selection in all interviews held after December 1979.

A working knowledge of spoken and written English was applied as a general criterion to all candidates. In general, it was found impossible to judge in a single interview how well candidates would perform in the field. Training sessions were therefore regarded as a further part of the selection process, with some candidates being rejected at this stage. A short list of acceptable investigators was drawn up after these training sessions from which names could be drawn as or when vacancies occurred, thereby reducing the absentee time in the field.

2). TRAINING

Each newly recruited batch of field investigators was given intensive training for several days at the Institute before being taken to the field. After a briefing on the objectives of the study, training consisted of two components:

a) Explaining the survey schedules both in English and Sinhalese.
b) Practical training in the use of schedules. Hypothetical questions and answers were put up on the blackboard, and the investigators were asked to complete the questionnaires, which were then checked carefully by the researchers. Subsequently,

the investigators were grouped into pairs and asked to act out the roles of farmer and interviewer. The answers entered on the appropriate questionnaires were checked and corrected by the researchers. Once they were in the field, the new recruits were guided by the permanent investigator, by already recruited casual investigators and by the researchers themselves.

Though each investigator was to be in charge of a farmer sample or an owner sample, all were given training in schedules relevant to each sample. This helped the investigators to understand the whole research project as well as to assist each other in the field. This helped the researchers to discuss with the investigators any matters outside their immediate sample interests.

Throughout the training and field work period schedules were made available in both English and Sinhala. In general, however, few difficulties were experienced with the interpretation of the English schedules used for data collection.

3) SUPERVISION

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 has been 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 scrunity 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 share 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, has been adhered to since the commencement of the field survey.A number of "surprise" visits have been made at each location in an attempt to guard against investigator absenteeism and data collection inadequacies.

Field investigators gather 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 are entered on to specially designed field note schedules before the final survey schedule is completed. In this manner a copy of the data is maintained for future use should any schedule become mislaid or prove incomplete. Sample owners willing to do so have been 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 is used in addition to the regular interview.

It is 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 are 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 are 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 is possessed to varying extents by each field investigator. However, by encouraging an active interest in the study and keeping them up to date with research progress the investigator team has been made aware of their value to the success of the project.

On our own part, the research staff have attempted to visit personally as many of the sample owners and farmers 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 cooperation. 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 has much the same effect.

2.4. 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 farmers 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 will be administered continuously through Maha and Yala seasons; others (acreages and harvests) will be 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 their samples and surroundings.

For the <u>owners'</u> schedules, a decision has to be 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 individual hiring operations, 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 <u>farmers</u> 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, followed by a summary of the content of each. Sample schedules are given in Appendix IX.

INDIVIDUAL SCHEDULE CHARACTERISTICS

1. <u>Owners Schedules</u>

(a) <u>Tractors and buffaloes - record of work done (Sch. A, A_1)</u>

This is the key schedule administered to owners. Data are collected separately for individual tractors, but jointly for buffalo herds. One schedule contains data for one week, entered by day, with a provision for multiple entries on any one day. Owners are classified according to the power type(s) they own, their residence status (on or off the scheme) and the degree to which a priori it is thought that income from non-farming activities contributes to their total income. Tractor registraion numbers are kept, with a provision for indicating whether they have in fact been registered.

As can be seen from Appendix IX this schedule will permit a breakdown to be made of the number of hours worked by agricultural operation, for whom the work was done, and what payment method was used. "Hours" are defined as time during which an operation is performed, not time adjusted to constant engine revolutions and does not include travelling time to and from the job, which will be calculated from separate mileage data collected on the same schedule. Data are also recorded on implement type, acreage covered, and reasons for any non-use.

(b) Financial transactions (Sch. A , A_{10})

For individual tractors and buffalo herds, a record is kept of expenditures on maintenance and repair of power sources and implements, by type of item purchased, including, for buffalo, the hiring of labour for herding. For tractors, expenditure on fuel by type is recorded. For buffaloes, income from the sale of milk, curd, etc., is recorded by item type.

(c) Opening stock (Sch. B, B_1)

For buffalo, an inventory was made at the start of the survey of the numbers owned by age and sex, and of implements by type. For tractors, the breakdown included age, fuel type and implement type as major components.

(f) Buffalo herd changes (Sch.C)

A monthly summary is kept of any changes to individual buffalo herds, by numbers, age and sex, reason for change and value of the changing component.

TABLE 6. SCHEDULES ADMINISTERED TO OWNERS 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 and sales of related items	monthly	Schedule A_o	September 1979
Tractor owners-record of maintenance, fuel and 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 1970
Buffalo and tractor-financial transactions	monthly	Schedule E	September 1979
Buffalo and tractor-sociology questionnaire	single-shot	- - -	March-April 1980
Buffalo and tractor-crop acreages	" "	Schedule 5A	March-April 1980
Buffalo and tractor-harvest details	" "	Schedule 6	March-April 1980
Buffalo owners closing stock	" "	Schedula Z	September 1980
Tractor owners-closing stock	" "	Schedule Z_1	September 1980

(e) Farming activities and financial transactions (Sch. D and E)

Schedule D is a modified version of Sch.1 (see below), being a monthly summary of the days spent on agricultural operations.

Schedule E is adapted from Sch.2 (see below), the section on incomings from hiring out power and on repairs to equipment etc., being deleted, the former because it was considered too sensitive an issue, the latter because it was already covered on Sch. A_{10}/A_0.

(f) Crop acreage (Sch. 5A)

For this schedule (modelled on Sch. 5), data are collected by asking the owners for their acreage of individual crops by season. For paddy, the percentage of the area transplanted is also asked from the owner.

(g) Harvest details (Sch.6)

See below.

(h) Closing stock (Sch. Z, A_1)

As for Sch. B, B_1, but at end of survey period.

2. Farmers Schedules

a) Physical farm inputs (Sch.1)

This is the most complex schedule in the data collection programme, and was used as a major criterion of ability in the selection of investigators. On it are recorded weekly totals of hours spent on individual farm operations, by crop land type, and worker category, with a provision for recording hours of power use by type, operation, owner/hirer status, implement and number of buffalo pairs. Other inputs such as fertilizer and insecticide are recorded in physical units during their week of application.

TABLE 7. SCHEDULES ADMINISTERED TO FARMERS 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 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	single-shot	Schedule 6	March-April 1980
Sociology questionnaire	single-shot	-	March-April 1980
Supplementary questions on source of water supply	" "	-	May 1980

(b) Financial Transactions (Sch.2)

Totals of incomings and outgoings are recorded under a variety of headings. For each sample member for a two-week period. Details of whether expenditure was on a cash or credit basis are included, as are details of the source of credit. Headings include: earnings from expenditure on labour;hiring in or out of machinery; purchase of inputs/sale of output;income from remittances; repayment of credit ; repairs to equipment; sale/purchase of farm capital equipment or household consumer durables.

(c) Start of season-status of cultiyation (Sch.3)

A simple survey designed to record what was being grown in the farmers' fields at the start of the survey, so as to provide a baseline for Sch.1 & 2. It also served the function of initially familiarising investigators with what their samples were doing.

(d) Dates on which farmers obtain water (Sch.4)

A daily record of whether or not farmers obtained water for their allotted lowland paddy, the purpose of which was to assist in detecting the magnitude and intensity of any water shortages, and to ascertain whether any published rotations were being practised.

(e) Survey of land resources (Sch.5)

The purpose of this investigation was to measure by compass and pacing the areas planted to specific crops, using the crop and land-type classifications specified for Sch.1. Additional information was obtained from the farmer on his own estimate of the relevant area, whether the land was rainfed or irrigated, his estimate of the area of any owned land type that remained unplanted and, for paddy, the percentage of the area transplanted and the number of liyaddes into which the allotted land was divided. This final statistic assumes importance particularly when mechanised power is used - the smaller the liyaddes, the more time is lost in turning. Finally, the investigator was asked to comment on the condition of the crop.

(f) Harvest details (Sch.6)

This schedule contains a breakdown by crop, variety and land type of the amount harvested by individual farmers, The week of harvest is noted, as is the planned distribution of the harvest among various uses (sale; retention for domestic use; payment for agricultural opeations).

(g) Sociology questionnaire

Although the economic investigations began in the field from August 1979, the sociology investigation was postponed unti March for two reasons. On the one hand, by delaying these investigations the investigators were able to study the location and farmers/owners by informal methods which would enhance the quality of subsequents data collected on sociological aspects. At the same time, the sociological investigations are not likely to be time-specific. The sociology questionnaire was administered to all the sample farmers and owners, the bulk of it being administered by the sociology investigators who were specifically recruited to study the populations by participant observations and had been doing so for nearly two months before the sociology investigations were implemented.

The questionnaire obtained data on such issues as household composition, household and other facilities, employment and farming experience, social linkages, power and leadership, farming experience, social linkages, power and leadership, development of farming activities, paddy land history, other land owned or operated, development of non-farming income-earning activities, ranking of all economic activities, water management, farm power types and selection criteria. There were specific questions to those who own farm power sources and for those who hire buffaloes/tractors, pertaining to problems of obtaining power sources when necessary, usage of farm power to optimum capacity, decisions on choice of different sources of power.

Aside from the specifically sociological issues in the investigation, a major aim of the questionnaire was to obtain data on income and wealth, among owners and farmers samples respectively, in order to test hypotheses relating to differential rates of wealth accumulation (particularly in the form of acquisition of control over land) among the various groups surveyed. As discussed earlier (cf. Sch. D/E), accurate income data are extremely difficult to obtain, and a circumspect approach was adopted for this investigation, the intention being to build up data on assets and business activities to permit, where necessary, and indirect assessment of income and wealth.

(h) <u>Supplementary questions on source of water supply</u>

Following field observations by the water management consultant (M.P.Moore) in April 1980,which suggested that water is frequently obtained from run-off from higher fields and not from field channels, an adhoc survey of sources of water supply was initiated. This will ask the <u>farmers</u> sample what proportion of their water is normally obtained from alternative sources at different times of season in both Maha and Yala. It will also try to ascertain how this proportion changes in such conditions as abnormally good or poor water supply.

3. Additional Data Collection

In addition to the regular collection of data from the samples several single-shot investigations were carried out. These include the direct measurement of grain moisture content both at harvesting and at threshing at all locations. These data will be of use in the consideration of alternative threshing technologies, some of which are sensitive to moisture content. Other data, such as daily rainfall and water issue records, are already kept by the respective scheme managements and will be copied by the research team in due course.

CHAPTER 3

PRELIMINARY RESULTS AND HYPOTHESES

3.1 FARM POWER POPULATIONS AT THE STUDY LOCATIONS*

1. The Context

A knowledge of the density and distribution of farm power within and among the study locations is important for several reasons:

i) The power owned by residents at each of the three study locations may vary in its composition among locations, and such variations may help to test hypotheses relating to, for instance, the timing of agricultural operations and power use-efficiency.

ii) The aggregate amount of power available(i.e. from 4-wheel tractors, 2-wheel tractors and buffaloes combined, with some appropriate weighting to take into account their work rates) may vary from one location to another, which would again help to shed light on hypotheses similar to the above.

iii) Spatial concentration of ownership of farm power may vary both by type and in the aggregate within study locations. Any such variation is likely to reflect:

(a) spatial variations in wealth, since tractors, in particular, represent the ownership of a substantial stock of wealth;

(b) the spatial availability on hire of the respective forms of power, since no power type is likely to be perfectly mobile within study locations.

iv) The concentration of farm power in the hands of individual owners may vary among power types and both among and within locations,

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* This section should be read in conjunction with the national level data discussed in Appendix VI.

with implications for potential exertion of monopolistic power in the hire market.

Data collected on the populations of each of the three main power types at the three study locations (and at Minneriya) to serve as a sampling frame in the early stages of the study were available for analysis in this connection.

The main results are presented below:

2. Overall Farm Power Populations

In Tables 8-11 a summary of the raw data is presented by tract for each location. Classifications are made by the three main power types(4 wt, 2 wt, and buffalo) and separate lists are presented for the power owned by farmers who are legally designated as allottees and others (usually small businessmen) who reside on the scheme, and may engage in farming, but not as officially designated allottees. This distinction is not made at Kaudulla, where no power is owned by residents on the scheme who are not also allottees, or at Minneriya, where data are available only for allottees.

At Uda Walawe and Padaviya, where sufficient data are available to permit comparisons between allottee and non-allottee ownership, we find that a high proportion of 4-wheel tractors are owned by non-allottees (36% and 29% respectively), the proportion of two-wheel tractors (1% and 3% respectively) and of buffaloes (27% and 9%)being lower.

These data are not inconsistent with the view that the transport potential of the 4-wheel tractor makes it an attractive proposition to small businessmen, who may or/not also use it for field work. Indeed, at Padaviya this is the predominant form of power owned by the non-allottees. At Uda Walawe the higher absolute numbers (and proportions) of buffalo and 2-wheel tractors owned by non-allottees than at Padaviya may be attributable to the inclusion of several well-established villages and of privately owned farming land within the boundaries of the Right Bank scheme.

3. Farm Power Densities Relative to Paddy Acreage

Comparison of the farm power densities and compositions at the study locations is facilitated by their reduction to a uniform acreage base. The overall size and paddy upland ratios of the study locations vary substantially (Tables II.1 - II.3) but one common feature is the low use intensity of land allotted for upland crops. This land comprises small vegetable plots, tree crops, and in some parts of Padaviya and Kaudulla is planted with a paddy crop in Maha which is for the most part rainfed, but frequently also given supplementary irrigation from whatever water source is at hand (including the illicit tapping of irrigation channels).

Only in the lower reaches of Uda Walawe is the highland extensively planted to annual non-paddy crops as envisaged in the project design. This is largely the result of the unreliability of irrigation water supply, which prevents full exploitation of allotted lowland in paddy cultivation.

Several options therefore exist for the selectinn of an appropriate base acreage which could he utilised in comparing farm power densities. Since highland allotments are seldom planted to annual crops (and, at Uda Walawe, where such planting does occur, farm power is available on hire, in principle at least from the scheme managemnt to assist in land preparation for "approved crops",such as cotton), it was decided to express farm power densities in terms of paddy acreage. In the study locations, where both Maha and Yala paddy are cultivated, it is theoretically possible to express farm power densities in terms of the Maha acreage or the Yala acreage, or an annual acreage comprising both. The main bottleneck in farm power availability, if any, would be likely to occur in land preparation for the main (Maha) season, and so this acreage was selected as the most appropriate. The effort was made to obtain figures reflecting as closely as possible the actual acreages planted to paddy, i.e. including encroachments onto reservations and the planting of paddy in what was designated as highlands. The paddy acreages adopted for this exercise thus differ from those in the initial

TABLE 8(a) UDA WALAWE - FARM POWER OWNERSHIP BY TRACT*

I.Power owned by allottees only.

Tract	4 W.T. No. Owners	4 W.T. No. Tractors	2 W.T. No. Owners	2 W.T. No. Tractors	Buffalo No. Owners	Buffalo No. Animals
2	1	1	9	9	4	243
3	0	0	14	14	3	125
4	1	1	13	16	11	730
5	2	2	15	16	0	0
6	2	2	22	24	2	80
7	1	1	9	8	0	0
Sub total:	7	7	81	87	20	1118
Chandrikawewa						
Tr 1 - 5	4	5	36	38	7	285
Tr 6	2	2	15	17	7	301
Extn. 1	8	9	25	26	3	100
Extn. 2	3	4	10	10	1	40
Sub total:	17	20	86	91	18	726
9	0	0	9	10	5	222
10	4	4	1	1	15	790
11	2	2	18	22	8	286
Sub total:	6	6	28	33	28	1298
12	3	3	39	49	22	621
13	2	2	7	7	1	38
14	1	1	15	16	2	96
Sub total:	6	6	61	65	25	755
15	0	0	6	6	7	94
16	0	0	5	5	6	271
17	0	0	15	16	13	360
18	0	0	0	0	0	0
19	0	0	0	0	1	30
Sub total:	0	0	26	27	27	755
Grand total	36	39	282	303	118	4652

* Note: In this and in subsequent Tables (8b-19), and in the associated discussion (Ch. 3.1-3.3), tractor population figures refer to all privately-owned tractors except those which have broken down and are not likely to be repaired. Buffalo populations are individual adult animals normally capable of field work.

TABLE 8(b) UDA WALAWE - FARM POWER OWNERSHIP BY TRACT

II. Power owned by non-allottees only.

Tract	4 W.T. No. Owners	4 W.T. No. Tractors	2 W.T. No. Owners	2 W.T. No. Tractors	Buffalo No. Owners	Buffalo No. Animals
2	2	2	4	4	0	0
3	0	0	0	0	1	100
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	1	1	0	0
Embilipitiya Town	7	7	9	10	0	0
Sub total:	9	9	14	15	1	100
Chandrika Wewa						
Tr 1 - 5	0	0	2	3	1	50
Tr 6	0	0	0	0	4	207
Extn. 1	0	0	0	0	1	25
Extn. 2	1	1	1	1	0	0
Sub total:	1	1	3	4	6	282
9	2	2	7	8	1	20
10	0	0	1	1	0	0
11	2	2	1	1	4	180
Sub total:	4	4	9	10	5	200
12	1	1	2	2	11	489
13	0	0	4	4	4	130
14	4	4	22	23	22	399
Sub total:	5	5	28	29	37	1018
15	2	3	2	2	8	156
16	0	0	0	0	0	0
17	0	0	0	0	0	0
18	0	0	1	1	0	0
19	0	0	0	0	0	0
Sub total	2	3	3	3	8	156
Grand Total	21	22	57	61	57	1756

TABLE 9 KAUDULLA - FARM POWER OWNERSHIP BY TRACT*

Stage I		4 W.T.		2 W.T.		Buffalo	
Tract No.	BOP No. Acreage	No. Owners	No. Tractors	No. Owners	No. Tractors	No. Owners	No. Animals
1 & 1b	1875	3	3	11	11	184	559
2 - 4	675	4	4	14	14	49	164
5	318	5	5	4	4	65	234
6	326	1	1	5	5	85	157
7	800	1	1	3	3	48	112
8	615	0	0	0	0	67	359
Stage I Sub total:	4609	14	14	37	37	498	1585
Stage II Tract No.							
1	246	0	0	1	1	37	97
2	490	2	2	3	3	66	137
3	300	0	0	0	0	17	38
4	914	0	0	2	2	35	77
5	202	0	0	0	0	30	61
6	734	0	0	0	0	80	244
7	370	0	0	0	0	90	213
8	400	0	0	0	0	71	177
9	720	2	2	4	4	55	223
10	468	0	0	2	2	16	50
11	407	0	0	0	0	21	54
12	684	0	0	0	0	78	206
Stage II Sub total:	5935	4	4	12	12	590	1577
Stage I + II Total	10544	18	18	49	49	1094	3162

* All owners are allottees.

TABLE 10(a) PADAVIYA - FARM POWER OWNERSHIP BY TRACT

I. Power owned by allottees only.

Lower Main Channel

Tract No.	Estimated Maha Paddy Acreage	4 W.T. No. Owners	4 W.T. No. Tractors	2 W.T. No. Owners	2 W.T. No. Tractors	Buffalo No. Owners	Buffalo No. Animal
1	154	3	4	3	3	14	213
2	523	7	7	10	10	9	108
3	231	6	7	1	1	9	106
4	111	7	7	1	1	17	327
5	604	15	20	5	6	23	413
6	2207	23	25	44	44	66	1215
7	557	9	9	11	11	33	528
8	438	4	4	3	3	26	415
9	1171	7	8	29	29	41	716
10	760	9	10	4	4	27	536
11	425	1	1	1	1	7	75
12	661	2	2	2	2	30	400
13	288	0	0	1	1	0	0
Sub Total:	8130	93	104	115	116	302	5052

Upper Main Channel

Tract No.	Estimated Maha Paddy Acreage	4 W.T. No. Owners	4 W.T. No. Tractors	2 W.T. No. Owners	2 W.T. No. Tractors	Buffalo No. Owners	Buffalo No. Animal
A	550	2	2	2	2	17	296
B	403	6	6	2	2	7	135
C	654	3	3	3	3	16	296
D	567	2	2	6	6	18	196
E	2016	5	5	5	5	207	1499
Sub Total:	4190	18	18	18	18	265	2422
Total:	12320	111	122	133	134	567	7474

TABLE 10(b) PADAVIYA - FARM POWER OWNERSHIP BY TRACT

II. Power owned by non allottees only.

Lower Main Channel

	4 W.T.		2 W.T.		Buffalo	
Tract No.	No. Owners	No. Tractors	No. Owners	No. Tractors	No. Owners	No. Animals
1	17	21	3	3	10	150
2	1	1	0	0	0	0
3	0	0	0	0	0	0
4	4	5	0	0	0	0
5	10	13	0	0	33	605
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	2	2	1	1	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
Sub total	34	42	4	4	43	755

Upper Main Channel

A	4	7	0	0	0	0
B	1	2	0	0	0	0
C	0	0	0	0	0	0
D	0	0	0	0	0	0
E	0	0	0	0	0	0
Sub total	5	9	0	0	0	0
Total	39	51	4	4	43	755

TABLE 11 MINERIYA - FARM POWER OWNERSHIP BY TRACT

Power owned by allottees only.

Tract	BOP Acres	4 W.T. No. Owners	4 W.T. No. Tractors	2 W.T. No. Owners	2 W.T. No. Tractors	Buffalo No. Owners	Buffalo No. Animal
Stage I							
Hingurakgoda, Hingurakdamana, Hathamuna, Hinguraka	3625	40	45	106	107	26	168
Rathmale	1436	1	1	1	1	27	202
Raja ela	1142	12	12	30	30	17	70
Sub total I	6203	53	58	137	138	70	440
Stage II							
Windsor Park	272	5	5	17	18	17	100
Stage III							
Yoda ela A & B	903	8	8	43	46	58	213
Kaudulla CDE	1591	14	14	101	108	219	886
Yalihalpathana	247	0	0	18	18	9	30
Sub total II & III	3013	27	27	179	190	303	1229
Stage IV							
Dulankadawala	594	6	6	19	20	100	290
Kusumpokuna	789	3	4	19	20	67	320
Viharagama	1179	2	2	13	13	92	280
Sub total	2562	11	12	51	53	259	890
Stage V							
Kirimetiyawa	668	5	5	19	19	81	271
Buddayaya and Galgamuna	2737	17	18	51	55	80	493
Sub total V	3405	22	23	70	74	161	764
Total	15183	113	120	437	455	793	3323

Blocking Out Plans, (Tables II.1 - II.3). It must be emphasised that such figures are approximate. For Padaviya they are estimated by the study team in consultation with scheme staff; at Uda Walawe by the RVDB and at Kaudulla by the Department of Agriculture staff. At Kaudulla the areas under the supervision of these staff do not correspond with the tract-wise irrigation layout, and so individual totals can be presented only for Stages I & II.

Presented in Tables 12-15 are the densities of each type of farm power per 1000 acres of paddy for each location. The totals represent densities for the scheme as a whole, whilst figures for individual tract groupings represent the densities of power owned within those tracts. For Uda Walawe and Padaviya, where an important component of the available farm power is owned by non-allottees resident on scheme, the data are presented for allottees only and for allottees and non-allottees combined. The results of this presentation are discussed first with reference to inter-location comparisons of farm power density, and then in relation to the distribution of densities within locations.

3.1. INTER-LOCATIONAL COMPARISONS OF FARM POWER DENSITY

Some striking differences in the densities of individual power types are noticeable. Padaviya, for instance, has the highest buffalo population density (probably attributable to the continued availability of grazing in the surrounding jungle areas) but also the highest 4 w.t. and a moderately high 2 w.t population. These tractor populations may be partly attributable to medium term credit programmes under the Tank Irrigation Modernization Project, but the particular inclination for 4-wheel tractors is difficult to explain unless it reflects the need for long distance transport in such a remote area (a notion consistent with the high ownership of 4 w.t by non-allottees) for which 2 w.t. would be inappropriate. The need for a higher horsepower tractor than the 2 w.t (to plough under dry conditions) in rainfed paddy cultivation outside the scheme may also have biassed the choice pattern in favour of the 4 w.t.

Whilst Minneriya and Kaudulla have lower buffalo populations than Padaviya, what is significant is that it has proved possible to continue to keep a substantial number of buffalo under a management system very different from that practised in most of the Dry Zone. At these schemes, livestock are generally tethered at the homestead and grass cut and carried to the animals, a system compatible with the large contiguous areas of paddy (c.60,000 acres) found in this vicinity, with grazing land available only at the peripheries. Perhaps this relatively high spatial concentration of paddy production, and of related services such as input supply and marketing, has encouraged the evidently high purchase of 2 w.t. there, a vehicle suited to field work and short-haul transport. The allocation of larger holding sizes in many parts of Minneriya scheme (5 acres of paddy and 3 acres of highland) and its relatively longer period of existence than that of the 3 study locations themselves may have permitted generation of wealth adequate for purchase of a power unit which was also broadly appropriate in scale to the average size of holdings, i.e. the 2 w.t.

The comparison of aggregate power availability among study locations is hindered by the variation in its composition and by lack of knowledge of its availability for custom work. We have however, attempted in Table 20 to estimate the paddy acreage that could potentially be cultivated by the observed farm power populations.

This analysis is, of course, both partial and static, insofar as it ignores the dynamics of demand, supply, costs and returns. It can be hypothesised that more or less work from the existing power stock will be forthcoming according to whether net marginal returns are higher or lower, which will in turn depend on the timing, composition and amount of demand for farm power at given locations, the way in which costs vary with increased operational time per power unit, and so on. It is thus impossible to make accurate predictions of what work-rates could or should be forthcoming from a given size and composition of power stock or, therefore, what power stock might be "necessary" to cultivate a given acreage. Analysis of the full year's use-data currently being collected will eventually permit an assessment to be made of what use-levels are normally achieved under given conditions, and so provide a useful base for predictions of higher/lower use-intensity under varied conditions. For the interim, our analvsis of early field data (3.2 below) suggests that current performance levels are remarkably uniform across locations, and therefore perhaps adds some validity to what remain the simplistic estimates made below in Table 20.

TABLE 12 UDA WALAWE

Farm power densities per 1000 acres of paddy (as cultivated in Maha 1978-79) by tract groupings at increasing distance from the headworks.

(A) Power owned by Allottees only — Density per 1000 acres Paddy (Maha only)

Tract Nos.	4 W.T.	2 W.T.	Buffalo
1 - 7	2.0	24.7	316.8
Chandrikawewa	4.4	19.8	158.8
9 - 11	2.5	13.9	548.6
12 - 14	1.3	14.1	163.9
15 - 19	0	11.0	307.2
All Tracts	2.2	17.3	265.0

(A + B) Power owned by allottees and non-allottees resident on-scheme.

Tract Nos.	4 W.T.	2 W.T.	Buffalo
1 - 7	4.5	28.9	345.1
Chandrikawewa	2.0	20.7	219.5
9 - 11	4.2	18.2	633.1
12 - 14	2.4	20.4	384.8
15 - 19	1.2	12.2	307.6
All Tracts	3.5	20.7	364.2

TABLE 13 KAUDDULA

Farm power densities per 1000 acres of (BOP) paddy by tract grouping at increasing distance from the headworks.[1]

	Density per 1000 acres paddy		
Stage I			
Tract No.	4 W.T.	2 W.T.	Buffalo
1 - 4	2.7	9.8	283.5
5 - 8	3.4	5.8	418.6
Sub Total Stage I	3.0	8.0	343.8
Stage II			
Tract No.			
1 - 6	0.7	2.1	226.6
7 - 12	0.7	2.0	302.7
Sub Total Stage II	0.7	2.0	265.7
Total Stage I + II	1.7	4.6	299.9

Note:

1. By contrast with Padaviya and Uda Walawe, data for Kaudulla are presented in only two tract groupings for each stage, representing upper and lower portions of those stages with roughly equal acreages. This presentation was thought preferable in view of the lower tractor densities and smaller sizes at Kaudulla.

TABLE 14 PADAVIYA

Farm power densities per 1000 acres of paddy (as cultivated in Maha 1978-79) by tract groupings at increasing distance from the headworks.

(A) Power owned by allottees only — Nos. per 1000 Acres

Tract Nos.	4 W.T.	2 W.T.	Buffaloes
1 - 5	27.7	12.9	719.0
A - D	6.0	6.0	424.6
6 - 10	10.9	17.7	664.3
E	2.5	2.5	743.6
11 - 13	2.2	2.9	345.7
All Tracts	10.0	10.9	606.7

(B) Power owned by allottees and non-allottees resident on-scheme — Nos. per 1000 Acres

Tract Nos.	4 W.T.	2 W.T.	Buffaloes
1 - 5	44.4	14.7	811.7
A - D	10.1	6.0	424.6
6 - 10	13.8	17.9	782.2
E	2.5	2.5	743.6
11 - 13	2.2	2.9	345.7
All Tracts	14.1	11.2	668.0

TABLE 15 MINNERIYA

Farm power densities per 1000 acres of (BOP) paddy by tract groupings at increasing distance from the headworks.

(A) Power owned by allottees only

		Nos. Per 1000 Acres		
Stage I	Acres	4 W.T.	2 W.T.	Buffalo
Hingurakgoda) Hingurakdamana) Hathamuna) Hinguraka)	3625	12.4	29.5	46.3
Rathmale	1436	0.7	0.7	140.7
Raja-ela	1142	10.5	26.3	61.3
	6203	9.4	22.2	70.9
Stage II				
Windsor Park	272	18.4	66.2	367.6
Stage III				
Yoda ela A + B	903	8.9	50.9	235.9
Kaudulla C,D,E	1591	8.8	67.9	291.6
Yalihalpathana	247	0	72.9	121.5
	3013	9.0	63.1	407.9
Stage IV				
Dulankadavala	594	10.1	33.7	488.2
Kusumpokuna	789	2.5	16.5	354.9
Viharagama	1179	33.4	17.0	271.4
	2562	4.7	20.7	347.4
Stage V				
Kirimetiyaya	668	7.5	28.4	405.6
Buddayaya & Galmuna	2737	6.6	20.1	180.1
	3405	6.8	21.7	224.4
All Tracts	15183	7.9	30.0	218.9

TABLE 16 UDA WALAWE

Ownership concentrations of farm power by tract groupings

(A) Power owned by allottees only — **Power units per owner**

Tract No.	4 W.T.	2 W.T.	Buffalo*
2 - 7	1.0	1.1	55.9
Chandrikawewa	1.2	1.1	40.3
9 - 11	1.0	1.2	46.4
12 - 14	1.0	1.1	30.2
15 - 19	-	1.0	28.0
All Tracts	1.1	1.1	40.4

(b) Power owned by allottees and non-allottees resident on scheme

Tract No.	4 W.T.	2 W.T.	Buffalo*
2 - 7	1.0	1.1	58.0
Chandrikawewa	1.3	1.1	42.0
9 - 11	1.0	1.2	45.4
12 - 14	1.0	1.1	28.6
15 - 19	1.5	1.0	26.0
All Tracts	1.1	1.1	36.6

* No of adults

TABLE 17 KAUDULLA

Ownership concentrations of farm power by tract groupings.

Stage I

Tract No.	No. power owner		
	4 W.T.	2 W.T.	Buffalo*
1 - 4	1.0	1,0	3.1
5 - 9	1.0	1.0	3.3
Average Stage I	1.0	1.0	3.1

Stage II

Tract No.	4 W.T.	2 W.T.	Buffalo*
1 - 6	1.0	1.0	2.5
7 - 12	1.0	1.0	2.8
AVerage Stage II	1.0	1.0	2.6
Average Stage I + II	1.0	1.0	2.8

* No of adults

TABLE 18 PADAVIYA

Ownership concentrations of farm power by tract groupings

(A) Power owned by allottees only

Tract No.	4 W.T.	2 W.T.	Buffalo*
1 - 5	1.2	1.1	16.2
A - D	1.0	1.0	15.9
6 - 10	1.1	1.0	17.7
E	1.0	1.0	7.2
11 - 13	1.0	1.0	12.8
All Tracts	1.1	1.0	13.2

(B) Power owned by allottees and non-allottees resident on scheme

Tract No.	4 W.T.	2 W.T.	Buffalo*
1 - 5	1.2	1.0	16.7
A - D	1.2	1.0	15.9
6 - 10	1.1	1.0	17.7
E	1.0	1.0	7.2
11 - 13	1.0	1.0	12.8
All Tracts	1.2	1.0	13.5

Power units per owner

* No of adults

TABLE 19 MINNERIYA

Ownership concentrations of farm power by tract groupings

(A) Power owned by allottees only	Power units per owner		
Stage I	4 W.T.	2 W.T.	Buffalo*
Hundurakgoda	1.0	1.0	7.3
Hingurakdamana	1.0	1.0	6.3
Hathamuna	1.4	1.0	7.1
Hinguraka	1.3	1.0	5.8
Rathmale	1.0	1.0	7.5
Raja-Ela	1.0	1.0	4.1
Sub total	1.1	1.0	6.3
II + III			
Windsor Park	1.0	1.1	5.9
Yoda Ela A.B.	1.0	1.1	3.7
Kaudulla D	1.0	1.1	3.7
Kaudulla C + E	1.0	1.0	4.5
Yatihalpathana South	-	1.0	3.3
Sub total	1.0	1.1	4.1
IV			
Dulankadavala	1.0	1.1	2.9
Wiharagama	1.3	1.1	4.8
Kusumpokuna	1.1	1.0	3.0
Sub total	1.1	1.0	3.4
V			
Kirimetiya	1.0	1.0	3.3
Buddayaya	1.1	1.0	6.2
Gal Amuna	-	1.7	5.7
Sub total	1.0	1.1	4.7
Total	1.1	1.0	4.2

* No of adults

On the basis of these estimates the aggregate power available within the Padaviya and Minneriya schemes seems comfortably adequate to cultivate the available paddy acreage; at Uda Walawe the aggregate density, whilst lower, remains adequate, whereas at Kaudulla it appears inadequate. These estimates are consistent with repeated casual observations by the study team of cultivations at Kaudulla by tractors introduced from outside the scheme, partly from the adjacent areas of Minneriya which, as we observe, appears to have a power capacity in excess of its requirements, and partly from more distant locations in the Wet and Intermediate Zones. If, as the estimates suggest, there is more power available at the study locations than would reasonably be necessary to cultivate the available acreages, such high power densities may go some way towards explaining the low use-intensities presented below (3.2)

TABLE 20 PRELIMINARY ESTIMATES OF FARM POWER TILLAGE CAPACITIES AT THE STUDY LOCATIONS

	Acreage capacities of:									
	(A)	A/D	(B)	B/D	(C)	C/D	(D)	(D) Total Potent-ial	(E) Total Actual	D/E
	4W.T	%	2 W.T.	%	Buffalo	%	%		%	
Uda Walawe	3250	14	7270	32	12304	54	22824	17553	130	
Kaudulla	1170	14	1068	13	6071	73	8309	11161	74	
Padaviya	7588	29	2965	11	15800	60	26353	12320	214	
Minneriya	7345	31	9919	42	6380	27	23644	15183	156	
All locations (excl.Minneriya)		21		20		59				
All locations (incl.Minneriya)		24		26		50				

Notes:
1) Acreage cultivated in a typical maha season, as given in Tables II.1 - II.3, with the exception of Minneriya, where only BOP data are available.
2) Assumed potential work rates as discussed in Appendis VI, Table VI.12. Note that even if the lower buffalo work rate assumption adopted by the FAO were incorporated here, the estimated potential would remain adequate at Minneriya, Padaviya and Uda Walawe.

A refinement in assumed work rates is incorporated here by taking the potential of 4 W.T. and 2 W.T. owned by businessmen to be half of those owned by farmers because of the higher off-farm commitment.

3.2 SPATIAL DISTRIBUTION OF FARM POWER OWNERSHIP WITHIN STUDY LOCATIONS

Also in Table 12 - 15 we consider the spatial distributinn of ownership within study locations. Although data were collected tract by tract, this unit of land was found to be too small to permit adequate comparisons of power density. Tracts were therefore aggregated into larger groupings on a somewhat arbitrary basis, the underlying principle beint to distinguish power ownership densities among groups of tracts with varying adequacy of water supply. Thus, at Padaviya, three groupings are made for the Lower Main Channel, and two for the Upper Main Channel. At Uda Walawe and Minneriya the tract groupings also correspond with administrative sub-divisions created by scheme management. At Minneriya, the variations in water supply over the scheme as a whole are small relative to other locations.

In spite of the relatively arbitary nature of the tract groupings, at all three study locations we observe a consistently declining concentration of 4 W.T. and 2 W.T. with increasing distance from the headworks. The same trend is not observed for buffalo ownership. These data are not inconsistent with hypotheses that:

(a) tractor ownership is largely a reflection of the greater wealth for purchase and hire of tractors at the upper ends of irrigation schemes;

(b) even where tail end farmers can afford to hire tractors they might find it difficult to do so because of observed spatial distribution patterns.

Significantly, for Minneriya, a scheme of relatively large holding sizes (mainly 5 acres of paddy and 3 acres of highland) and of equitable water availability, the spread of ownership is comparatively even over the scheme as a whole.

4. OWNERSHIP CONCENTRATIONS OF FARM POWER

It is possible to hypothesise that a high concentration of farm powre in the hands of few individuals will generate market structures conducive to monopolistic behaviour in power-hiring markets. Such a possibility is of strong interest to this study and, accordingly, the farm power population data were examined both by tract groupings within schemes and for the entire locations for any high concentrations of ownership.

At all locations it was found that the prevalent pattern was for an individual owner to possess only one tractor, whether 4 W.T. or 2 W.T. regardless of whether he was an allottee. With buffalo ownership, however, significant variations in the pattern across(but not within) study locations were observed. At Uda Walawe, and to a lesser degree at Padaviya, the average number of buffalo per owner was high (per allottee, 40 and 13 adult animals respectively) whereas at Kaudulla and Minneriya it was low (3 and 4 respectively). At Uda Walawe a declining trend in herd size/owner was observed with increasing distance from the headworks, although tests for statistical significance have not yet been made.

The differences in ownership concentration between Uda Walawe/Padaviya, on the one hand, and Kaudulla/Minneriya on the other, correspond with the above-mentioned differences in buffalo hunsandry practices. Open grazing is practised at the former, whereas tethering and stall-feeding are practised on the latter. With expanding arable farming in the Dry Zone, it is clear that the supply of grazing land will be reduced, and if animals are to continue as a significant source of draught power, pressures for more widespread tethering and stall-feeding of small individually owned herds will mount. We would suggest tentatively that a high incidence of ownership with low average herd sizes as observed at Kaudulla and Minneriya has several potential advantages, viz:

- i) a more even spread of potentially income-generating assets
- ii) higher potential use-efficiency of buffalo with the reduced management problems of contract work in smaller herds;
- iii) the possibility of a higher degree of competiton among owners for hire-work, with associated increased efficiency and reduced charges.

At this stage in the research, it is possible to touch only briefly on the requirements for and prospects of such a change in animal husbandry systems. The following preliminary hypotheses are advanced:

i) In spite of the fact that preliminary economic calculations (e.g. Farrington et.al, forthcoming) suggest that the wider use of animal power would be financially attractive both to the farmer and to the national economy, in addition to placing the timing and quality of cultivation more firmly under the farmer's control, the more widespread ownership of animals would require the initial problems of lack of investable funds and aversion to risk (disease, theft, re-sale price fluctuations) among small farmers to be overcome.

ii) Additionally, reproduction of existing stock is both haphazard in quality and uniformly low in quality, with problems of disease, malnourishment and high calf mortality. Markets for the purchase or sale of working animals are virtually non-existent (FAO, 1980).

iii) Fundamental questions about attitudes towards work and leisure require investigation before a more widespread ownership and use of draught animals can be confidently predicted. Have farmers become so accustomed to the lower demands on their time and effort made by tractorised land preparation that they are unwilling to revert to animal cultivation unless the gap in cash outlay between the two systems becomes particularly large?

iv) Even if an analysis of farmers' attitudes and circumstances in the above issue gives rise to optimism, it remains clear that the more widespread ownership and use of animal draught is fraught with problems outside the farmer's control, and optionally sponsored programmes would be necessary. These include: the establishment of centres for the purchase and sale of young or working animals; the promotion of improved stock breeding; improved disease control; the dissemination of husbandry techniques and (initially) subsidised/assisted production and marketing of improved fodder (possibly on homestead plots, which are currently under-utilised, and possibly also the provision of medium-term credit for the purchase of animals and equipment).

Thus, no matter now compelling might be the arguments for a more widespread ownership of working animals in smaller herds, kept under a tethering and stallfeeding system, it is clear that such a radical departure form the large herds and open grazing systems commonly found in the Sinhala Dry Zone faces a number of uncertainties and difficulties. Further work will attempt to shed light on these, but for the interim it is clear that excessive haste or optimism in officially-sponsored programmes would be unwise.

Our analysis of farm power population data in this section permits a number of firm conclusions to be drawn, and suggests hypotheses for subsequent analysis. These are summarised below.

1) The size and composition of farm power ownership across study locations and among owner types appears to conform well with variations in local tillage and transport requirements and resource (especially grazing) endowments. This may appear an obvious conclusion, but is also a useful pointer towards the general validity of the data. Our estimates of tillage capacities, whilst necessarily crude, suggest that at most locations there is an excess, not a shortage, of farm power.

2) Tractors of both type show a consistent decline in distribution density with increasing distance from the headworks at those three locations where tail end water problems are experienced. The density is more evenly spread at Minneriya, where water problems are rare. Tractors are thus clearly a part of the asset-structure of those sectors of settler communities which are better placed to acquire wealth through proximity to service centres, good roads and, above all, regular and abundant irrigation water supplies. At the lower ends of schemes the poverty attributable in large part to the lack of these facilities is likely to be compounded by the irregular availability of tractor services resulting from the imbalance in the spatial distribution of their ownership. Possible implications of this distribution of power for the ownership and control of other productive resources, especially land, are discussed in the sociology section below (3.5).

3)Buffalo populations do not exhibit this tendency. This could be explained in several ways: such large sums of money are not required for the initial purchase of buffalo; some of the largest buffalo owners, whom one might expect to have found among the wealthier (i.e. top end) sectors of the community may have sold or reduced their herds with the acquisition of tractors; grazing land may be more readily available at the tail ends of some command areas where cropping intensity is low.

4)The ownership concentration of tractors is low (generally one per owner) but for buffalo is high at Padaviya and very high at Uda Walawe. This gives rise to fears that monopolistic practices may occur among buffalo owners at these two locations, and that it may be impossible to manage such large herds with enough flexibility to meet the requirements of the hire market. Subsequent analysis will examine both of these possibilities more rigorously. For the present it is perhaps adequate to state that the former anxiety may be unfounded since in theory the possibility of emergence of monopolistic power will depend more on the overall number of enterprises in a given market than on the size of those enterprises (e.g. buffalo owners) at one location vis a vis any other location. The absolute number of tractor owners is lower at all locations than the number of buffalo owners (except for 2 w.t. at Uda Walawe), and since it would seem reasonable for other reasons (i.e. escalation of operating costs) to expect tractor owners to be the hire-price leaders, it seems reasonable to hypothesise that the prospects of collusive behaviour among tractor owners are higher than among buffalo owners. The attempt to discover whether such collusion does exist will be made when hire-charge data become available for analysis.

3.2. FARM POWER USE HOURS RECORDED AT THE STUDY LOCATIONS(26/8/79-19/1/80)*

1. The Context

The use intensity of farm power, expressed in terms of hours of use over a given time period, is a key statistic in planning appropriate levels and

*This section should be read in conjunction with the broader discussion in Appendix VI.

combinations of the stock of farm power to meet agricultural and transport requirements, and in designing strategies to obtain adequate use-levels from existing stocks. Additionally, considerations of both production and income distribution suggest that use-intensity should be analysed spatially (within command areas) and by owner-type (whether businessman or small farmer).

It might, for instance, be hypothesised that the observed concentration of tractors at the top ends of command areas lead to limited and uncertain availability and therefore might constrain productinn at tail ends. Some reflection of varying availabilities might be evident in differences in use-hours. Similarly, it may be contended that if tractors are owned by businessmen and not by farmers they will tend to be allocated to non-agricultural uses. The extent to which this is detrimental to national economic welfare is complex and is discussed in a preliminary fashion below. Our data permit preliminary testing of these hypotheses.

2. The Data

Field data are currentlv available for the period 26/8/79 to 19/1/80, these being the first 20 weeks of the field survey. The period covers the entire Maha 1979-80 land preparation at all locations, and the Yala harvest at all sites though in differing proportions: at Kaudulla, the entire scheme cultivated paddy as a Yala (1979) crop, with virtually no break between Yala harvest and Maha land preparation; at Padaviya only some 3400 of the 12000 acres were planted to Yala paddy, and at Uda Walawe Yala paddy was not grown in the lower tracts (esp. parts of Tr. 18 and Tr. 19).

These data are analysed in terms of the average number of hours worked per power unit (excluding travelling time to and from work) over the period. The following classifications are made:

i) Average hours/power unit at each location
ii) Average hours/power unit in agricultural and non-agricultural operations at each locations

iii) Average hours/power unit in all operations by spatial distribution of ownership at each locations.

iv) Average hours/power unit in agricultural and non-agricultural operations by spatial distribution at each location.

v) Average hours/power unit for all operations by owner category at each location.

vi) Average hours/power unit for agricultural and non-agricultural operations by owner category at each location.

vii) An additional category is superimposed on the operation type, locational and owner-type classifications, namely whether the recorded work was done on the owner's account ("self"), or on a "loan or hire" basis.

viii) Finally, use-hours curves by week over the 20 weeks of observations for each power type are presented for the individual locations (figs. 1-3), and for the breakdown between agricultural and non-agricultural work by week (figs. 4-9).

These classifications can now be discussed in turn.

(i) AVERAGE HOURS WORKED/POWER UNIT BY LOCATION (TABLE 21)

The overwhelming impression is one of very low use-intensity. For both types of tractor and for all operations the average at each location lies in the range 10-15 hours/week. For buffaloes, it is some 7 hours/pair/week over the 20 week period. These figures for all power types include work done at the busiest time of year, i.e. Maha land preparation. When data are available for the full 12 months of field work an even lower weekly average may emerge. International comparisons of tractor use-data are not readily available, but in a tractor pool operated for smallholders in Swaziland a weekly average over 12 months of some 20 hours/tractor was obtained (McKinlay, pers. comm.). It is highly likely that overall low use-intensities are, to a large extent, simply a reflection of excessively high power densities (3.1 above) and an inelastic supply of use-opportunities. They may also reflect non-commercial attitudes towards capital at both national and individual levels. This possibility is discussed in some depth below (3.3). For the present discussion there appears to be little

TABLE 21 AVERAGE NUMBER OF HOURS WORKED PER POWER UNIT FOR THE PERIOD OF 26TH AUGUST 1979 TO 19TH JANUARY '80.

	Work done for	Operation category	4 W.T. Location within command area Top	Bottom	All	2 W.T.** Location with command area Top	Bottom	All	Buffalo Pair Location within command area Top	Bottom	All
UDA WALAWE	Self :	(Agriculture *	3.2	18.8	8.0	35.5	15.5	28.1	12.8	0.8	6.3
		(Non-Agriculture	28.7	-	14.3	50.4	6.9	34.3	-	-	-
		(Both	31.9	18.8	22.3	85.9	22.4	62.4	12.8	0.8	6.3
	Loan or Hire	(Agriculture	61.6	111.2	86.4	103.6	147.6	119.9	188.6	80.1	129.8
		(Non-Agriculture	289.5	73.7	181.6	105.8	43.7	82.8	-	-	-
		(Both	351.1	184.9	268.0	209.4	191.3	202.7	188.6	80.1	129.8
		Total hours/power unit	383.0	197.0	200.3	295.3	213.7	265.1	201.4	80.9	136.1
KAUDULLA	Self :	(Agriculture	25.3	52.3	32.8	121.3	133.5	127.9	131.5	130.5	130.8
		(Non-Agriculture	34.3	31.0	33.0	35.1	66.5	49.5	-	0.3	0.2
		(Both	59.6	83.3	65.9	156.4	200.0	177.4	131.5	130.8	131.0
	Loan or Hire	(Agriculture	94.2	84.3	93.7	22.6	22.0	23.4	13.7	4.9	7.5
		(Non-Agriculture	85.7	39.1	77.8	15.7	36.7	24.8	-	-	-
		(Both	179.9	123.4	171.5	38.3	68.7	48.2	13.7	4.9	7.5
		Total hours/power unit	239.5	206.7	237.4	194.7	258.7	225.6	115.2	135.7	138.5
PADAVIYA	Self :	(Agriculture	47.5	103.1	64.7	155.6	160.0	156.9	68.6	96.9	75.1
		(Non-Agriculture	12.6	43.7	22.3	27.8	51.6	34.8	-	-	-
		(Both	60.1	146.8	87.0	183.4	211.6	191.7	68.6	96.9	75.1
	Loan or Hire	(Agriculture	150.3	229.3	175.0	102.5	129.8	110.7	42.9	103.3	56.6
		(Non-Agriculture	38.1	51.3	42.7	15.4	50.9	26.0	-	-	-
		(Both	188.4	281.2	217.7	117.9	180.7	136.7	42.9	103.3	56.6
		Total hours/power unit	248.5	428.0	304.7	301.3	392.3	328.4	111.5	202.2	131.7

* Agricultural operations are defined to include the transport of agricultural goods.

** For Uda Walawe, top includes Tracts 2-7 and Embilipitiya Town
For Kaudulla, top includes the upper end of Tract 1 and the sample drawn from Minneriya
For Padaviya, top includes Tract 2, Padaviya Town, Tracts 7-9 & E.

preparation practices also vary among locations, with buffaloes being used extensively for trampling ("mudding") at Uda Walawe. This may be attributable to both soil type and liyadde-size characteristics and will be explored more fully in subsequent work. For the present, it may be taken as additional grounds for the low use of tractors in agriculture there.

(iii) AVERAGE HOUR/POWER UNIT BY SPATIAL DISTRIBUTION OF OWNERSHIP AT EACH LOCATION (TABLE 21)

For Uda Walawe, the top end shows higher use-intensity of all power types, whereas the reverse is true of Padaviya. For Kaudulla, the top/bottom distinction for the <u>owners</u> sample, in terms of general levels of water availability and wealth, are not strong, and differences in use intensity for each power type are neither strong nor consistent. Whether wealth and water availability play a strong role in determining power use-intensities at the other locations is an issue that cannot be discussed in full at this stage. Some preliminary suggestions of the reasons for observed variations can, however, be made: at Uda Walawe, the use-opportunities, particularly in transport, appear to be more abundant at the top end (see above); at the bottom end, the age-structure of tractors appears to be higher with a corresponding reluctance to put them into heavy agricultural work. At Padaviya, extensive tracts of misappropriated land and encroached Crown Land are known to have been put into cultivation near the bottom end of the scheme, and the tractor population there is relatively low (Table 14), possibly accounting for the observed higher use-intensities.

(iv) AVERAGE HOURS/POWER UNIT IN AGRICULTURAL AND NON-AGRICULTURAL OPERATIONS BY SPATIAL DISTRIBUTION AT EACH LOCATION (TABLE 21)

The main components of these observations have already been discussed above: the exclusive use of buffaloes in agriculture in all parts of the locations; the heavy involvement of tractors in agricultural operations at both top and bottom of Padaviya, and the intermediate position occupied by Kaudulla, with little difference in use-patterns between the two sub-locations within the scheme.

variation in the total hours worked/ power unit among the three locations. For buffaloes, it is remarkably consistent at some 130-140 hours over the 20 week period. (Table 21). For 2 w.t. it varies from 225 to 320 hours and for 4 w.t. from 237 to 304 hours. Such variations as do exist among schemes cannot easily be explained in terms of power populations(Table 15-19). On the contrary, Padaviya, for instance, has the highest 4 w.t. population, but also the the highest use-level. It would seem that both the seasonal inflow of power on to schemes (as happened at Kaudulla particularly for the reference period) will depress use-intensity of the resident power stock to a level lower than might be anticipated, and that use-opportunities outside the area of reference may raise use-levels even where population densities appear high (at Padaviya, part of the high recorded use may be attributable to work in semi-dry tilling outside the scheme). For the period observed there appears to be little difference in the overall use-intensities between 2.w.t. and 4 w.t. This might be explained by the fact that Maha land preparation, equally opportune for both 2 w.t. and 4 w.t., forms a major component of the work observed during the period. In whole season observations, the greater adaptability of 4 w.t. for transport may increase the use-hours disparity.

(ii) AVERAGE HOURS/POWER UNIT IN AGRICULTURAL AND NON-AGRICULTURAL USE (TABLE 21)

At all locations, as would be expected, buffaloes are deployed exclusively in agricultural use. For 2 w.t. also, agricultural work forms the bulk of use-hours(some 81% at Padaviya; 67% at Kaudulla and 56% at Uda Walawe). For 4 w.t. the proportion of work done in agriculture is slightly lower (79%, 53% and 33% respectively). This finding is consistent with the greater suitability of the 4 w.t.for transport work. It is interesting to note that for both tractor types use in agriculture is highest at Padaviya and lowest at Uda Walawe. The non-availability of alternative (transport) work at a remote location such as Padaviya is no doubt part of the explanation, and the strong commercial pull of Embilipitiya (at Uda Walawe) to which both 4 w.t. and 2 w.t. provide a "bus" service, the 4 w.t. also being engaged in transport work for the nearby Paper Corporation,[1] provides a further possible explanation. Customary land

[1] There are also several large rice mills in the area, and a ceramics factory at nearby Hungama, all of which hire transport.

(V) AVERAGE HOURS/POWER UNIT FOR ALL OPERATIONS BY OWNER CATEGORY AT EACH LOCATION (TABLE 22)

As discussed above (2.2) only a provisional distinction could be made between those owners relying predominantly on farming for their income, and those relying predominantly on other business activities. This distinction will be revised in due course when income data become available. For the present the distinction is provisional, and the data presented here must be regarded as tentative. For 4 w.t. at Kaudulla and Uda Walawe, "businessmen" seem to obtain higher use levels, whereas at Padaviya there is little difference. This observation corresponds with a general notion that owners who are strongly business-oriented will have both greater opportunity, and greater incentive, to obtain higher use - levels for their tractors. Similar observations are made for 2 w.t. at Kaudulla and Padaviya. The deviation from the trend for 4 w.t. at Padaviya may be attributable to the long-term breakdowns suffered by one businessman multiple-owner of 4 w.t. there. No immediate explanation is available for the lack of difference between the two owner categories for 2 w.t. at Uda Walawe. For buffaloes, the same trend of greater use-intensity by "businessmen" is observed, except, of course at Padaviya, where no buffaloes were kept by sample "businessmen".

(vi) AVERAGE USE-HOURS/POWER UNIT FOR AGRICULTURAL OPERATIONS BY OWNER CATEGORY AT EACH LOCATION (TABLE 23)

In Table 23 we extract from Table 22 the percentage of use-hours/tractor spent in non-agricultural operations by owner type. The evidence is remarkably consistent for both types of tractor and at all locations:

TABLE 23 PERCENTAGE OF TRACTOR USE-HOURS IN NON-AGRICULTURAL OPERATIONS BY OWNER CATEGORY (26.8.79 - 19.1.80)

	4 W.T.		2 W.T.	
	Businessmen % hours	Farmers % hours	Businessmen % hours	Farmers % hours
Uda Walawe	72.3	57.5	50.0	38.6
Kaudulla	53.6	36.4	45.9	31.0
Padaviya	28.4	11.8	19.5	18.3

TABLE 22 AVERAGE NUMBER OF HOURS WORKED PER POWER UNIT BY CATEGORY OF OWNER, 26TH AUGUST 1979 TO 19TH JANUARY 1980.

		Operation category	2 W.T. Owner category		2 W.T. Owner category		Buffalo pair Owner category	
			Businessmen	Farmers	Businessmen	Farmers	Businessmen	Farmers
UDA WALAWE			N = 11	N = 9	N = 14	N = 12	N = 20.5	N = 230.5
	Work done for : Self	(Agriculture	2.3	14.2	33.9	28.5	11.1	6.7
	:	(Non Agriculture	24.2	2.9	52.6	14.2	-	-
	Loan Hire	(Agriculture	82.2	91.4	93.7	138.2	277.5	116.7
		(Non Agriculture	196.0	140.1	75.0	90.8	-	-
		All operations	304.6	248.7	255.2	271.7	288.6	123.4
KAUDULLA			N = 6	N = 12	N = 6	N = 19	N = 13.5	N = 75.5
	Self :	(Agriculture	36.3	34.9	132.5	125.4	133.0	130.4
		(Non Agriculture	57.4	18.8	93.8	39.8	-	-
	Loan Hire	(Agriculture	91.9	91.4	31.3	20.5	17.4	5.0
		(Non Agriculture	90.9	53.5	45.3	25.7	-	-
		All operations	276.5	198.6	302.9	211.4	150.4	135.4
PADAVIYA			N = 17	N = 12	N = 4	N = 17	N = 0	N = 174
	Self :	(Agriculture	56.6	76.3	152.8	155.2	0	75.1
		(Non Agriculture	27.1	15.4	46.5	31.2	0	-
	Loan Hire	(Agriculture	153.2	205.9	206.5	82.2	0	56.6
		(Non Agriculture	56.2	22.4	40.8	21.9	0	-
		All operations	293.1	320.0	446.6	290.1	0	131.7

Note : N refers to the number of tractors of buffalo pairs, not to the number of owners.

Businessmen allocated a higher propotion of their tractor use-time to non-agricultural activities than farmers did. Returning to the data in in Table 22, it is clear that for both tractor types at all locations businessmen devote some 50% - 100% more tractor time to non-agricultural activities than do farmers.

This finding, if confirmed by subsequent analysis of data currently being collected, is of some significance for policies designed to introduce tractors as a predominantly agricultural investment, an investment whose opportunity cost is high at peak agricultural seasons. It may indicate a disparity between private and social costs and benefits at this time of season. (See 3.3 below).

(vii) USE-HOURS FOR OWNERS THEMSELVES AND ON LOAN/HIRE (CONTRACT WORK) (TABLES 21-22; 24-25)

Data on the division of work between the owners' personal requirements and loan/hire requirements ("contract" work) are extracted from Table 22, and presented separately in Table 24. Across all locations, 4 w.t. are hired out more than any other power type, suggesting that their much higher work capacity is not matched by correspondingly higher use-opportunities (farming or otherwise) in the hands of owners. The only exception to this trend is buffalo hiring at Uda Walawe, which accounts for a high proportion of their use-time because of the very large herd sizes there, the proportion of contract work at Padaviya and Kaudulla declining in line with smaller herd sizes (cf. Tables 16-19).

It is interesting to note that 2 w.t. hiring is much lower at Kaudulla than else where. The researchers were repeatedly told informally by owners there that they had bought 2 w.t. primarily for their own farming and transport needs, and were not concerned with hiring them out. This may correspond with some variation in holding size between 2 w.t. owners there and elsewhere, a possibility which will be followed up in further analysis of the data. What is certain is that the drivers of 2 w.t. are usually also the owners, (whereas with other power types separate drivers are normally employed) with the result that the scope for hiring work is constrained by other pressures on the owner's time, a factor which may influence them to purchase 2 w.t. with essentially their own requirements in mind.

TABLE 24 PERCENTAGE OF TOTAL USE-HOURS/POWER UNIT SPENT ON CONTRACT (LOAN/HIRE) WORK BY OWNER TYPE (26.8.79-19.1.80)

	Businessmen % total hours	Farmers % total hours	Businessmen % total hours	Farmers % total hours	Businessmen % total hours	Farmers % total hours
Uda Walawe	91	93	66	84	96	95
Kaudulla	66	73	25	22	12	4
Padaviya	71	71	55	50	0	43

TABLE 25 PERCENTAGE OF CONTRACT HOURS (LOAN/HIRE) SPENT ON AGRICULTURAL OPERATIONS, BY OWNER TYPE (26.8.79-19.1.80)

	Businessmen % of contract time	Farmers % of contract time	Businessmen % of contract time	Farmers % of contract time	Businessmen % of contract time	Farmers % of contract time
Uda Walawe	29	39	56	60	100	100
Kaudulla	50	63	41	44	100	100
Padaviya	73	64	84	79	0	100

These factors constraining the scope for hiring-out of 2 w.t. are clearly of importance at the policy level. It does not appear to be in the national interest to tie up capital in assets for which inadequate use-opportunity can be found. As it is, the agricultural use-potential for tractors is highly seasonal; the use-efficiency of capital is further impaired if at least some owners cannot or will not hire them out even during the peak demand season. Yet, this attitude towards capital may not be irrational from the owner's private point of view. The need to reconcile national and private interest in tractor ownership and use is an issue discussed separately below (3.3). For the present discussion, it would seem that the problem of obtaining higher use-levels from 2 w.t. without going to the lengths of permitting 2 w.t. owners legal access to large holdings - involving a break with current settlement philosophy unlikely to be acceptable to policy makers - is a thorny one indeed.

Fig. 1. Average use-hours per week for 4 WT at all Locations (26.08.79 - 19.01.80)

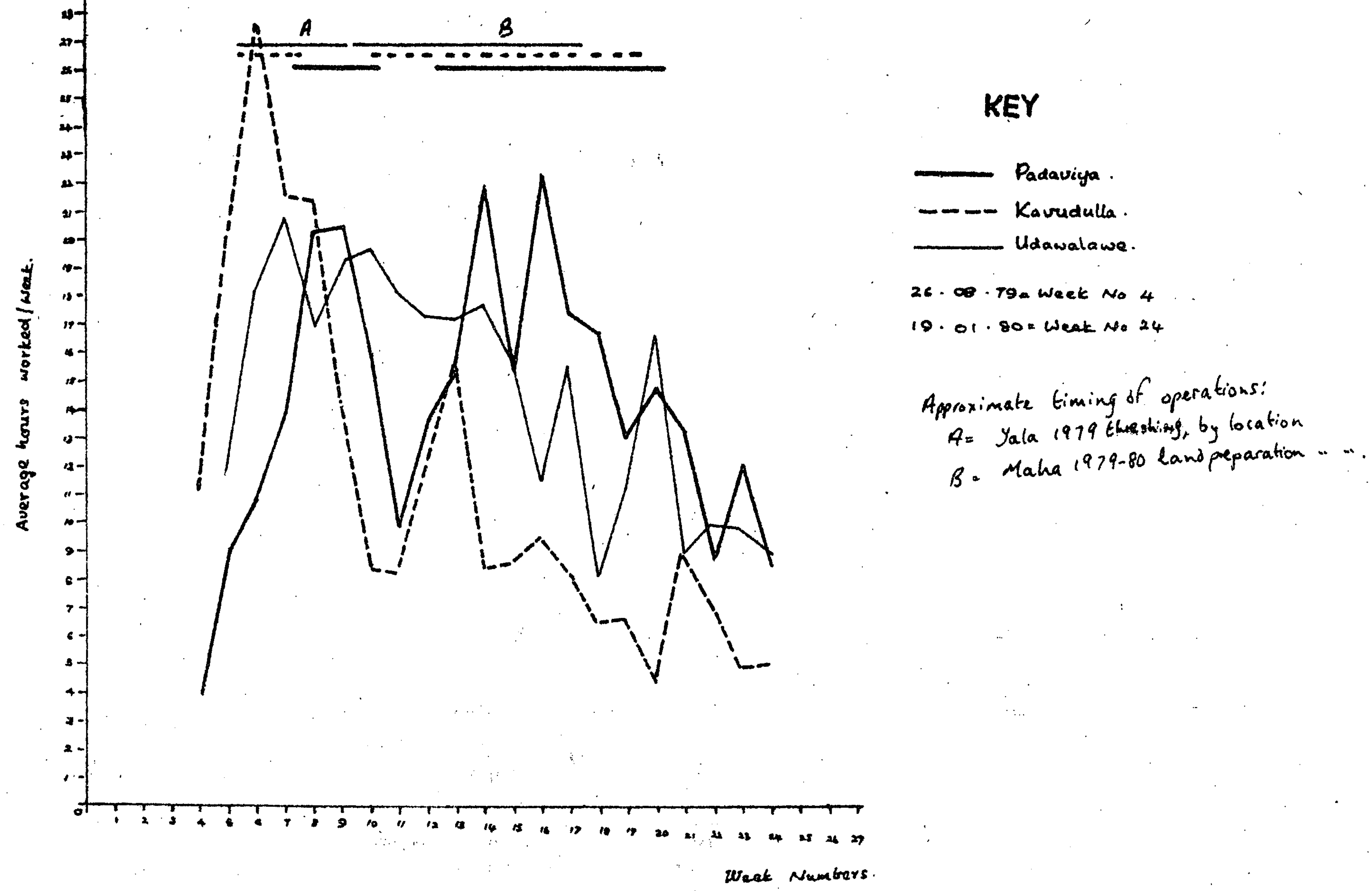


Fig. 2 Average use-hours per week for 2wt at all Location (26.08.79 – 19.01.80)

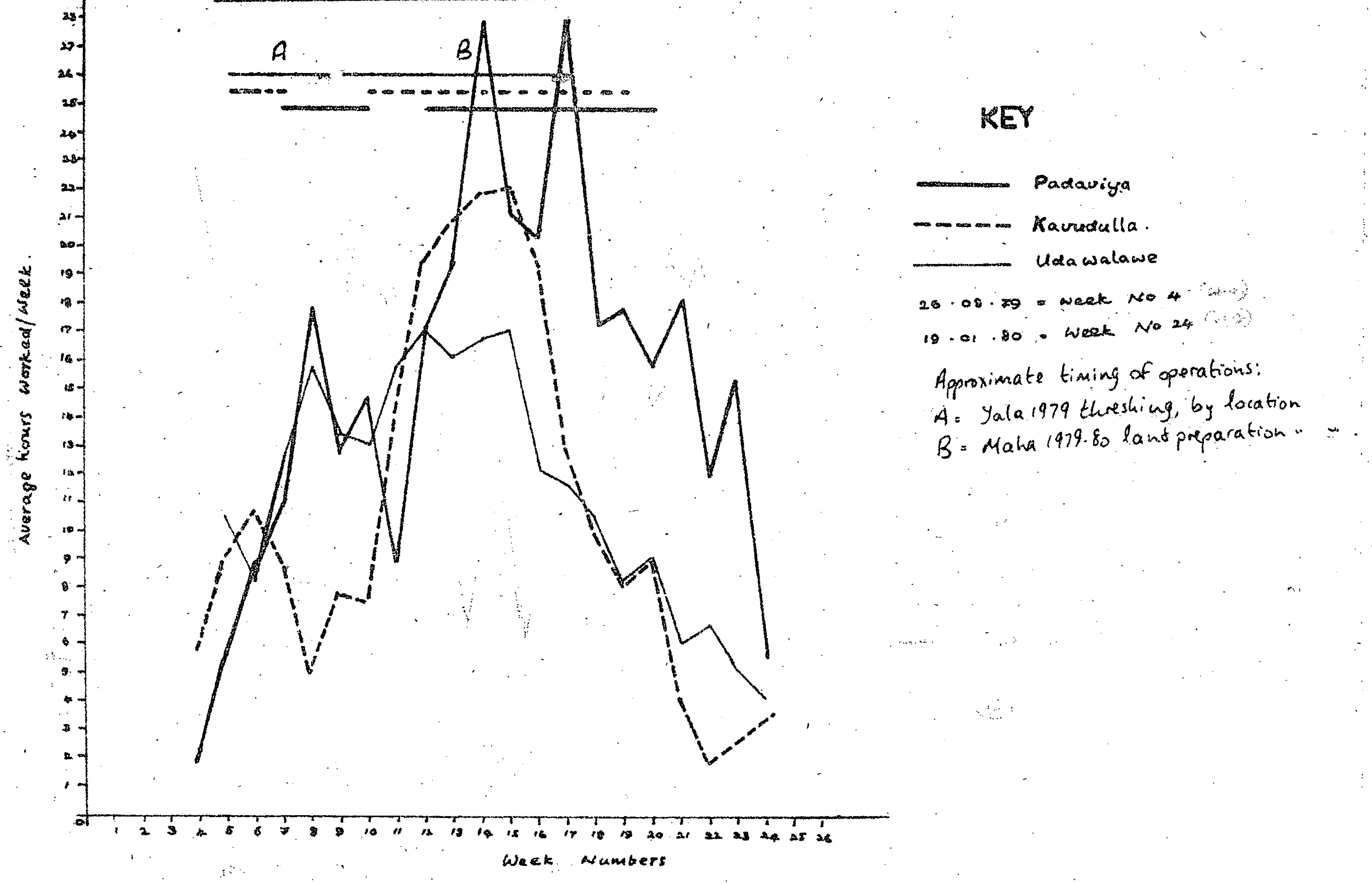


Fig. 3 Avarage use-hours per week per buffalo pair at all locations (26.08.79 - 19.01.80)

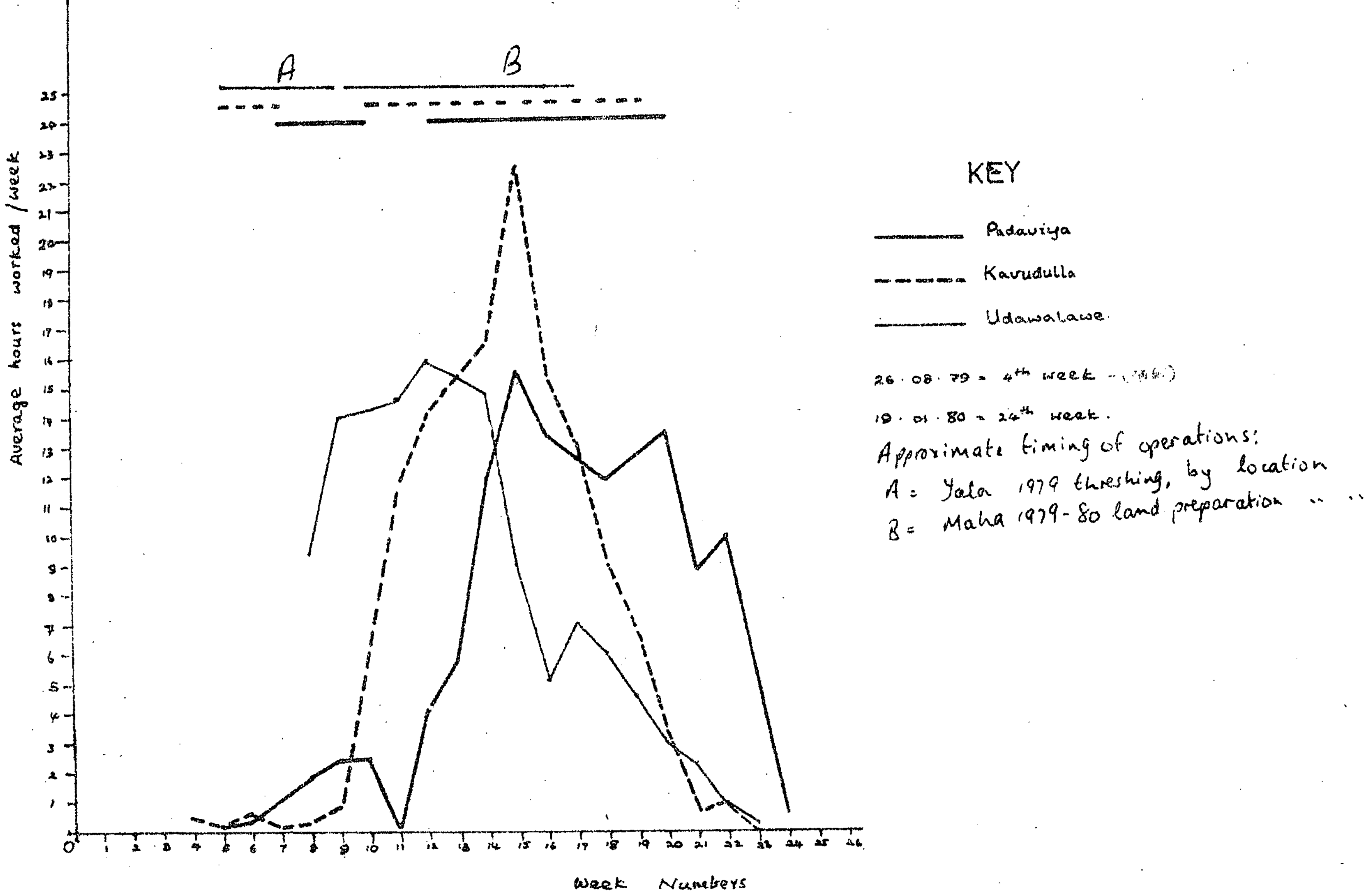


Fig. 4 Average use-hours per week for 4 wt at Udawalawe – (26.08.79 – 19.01.80) by type of work

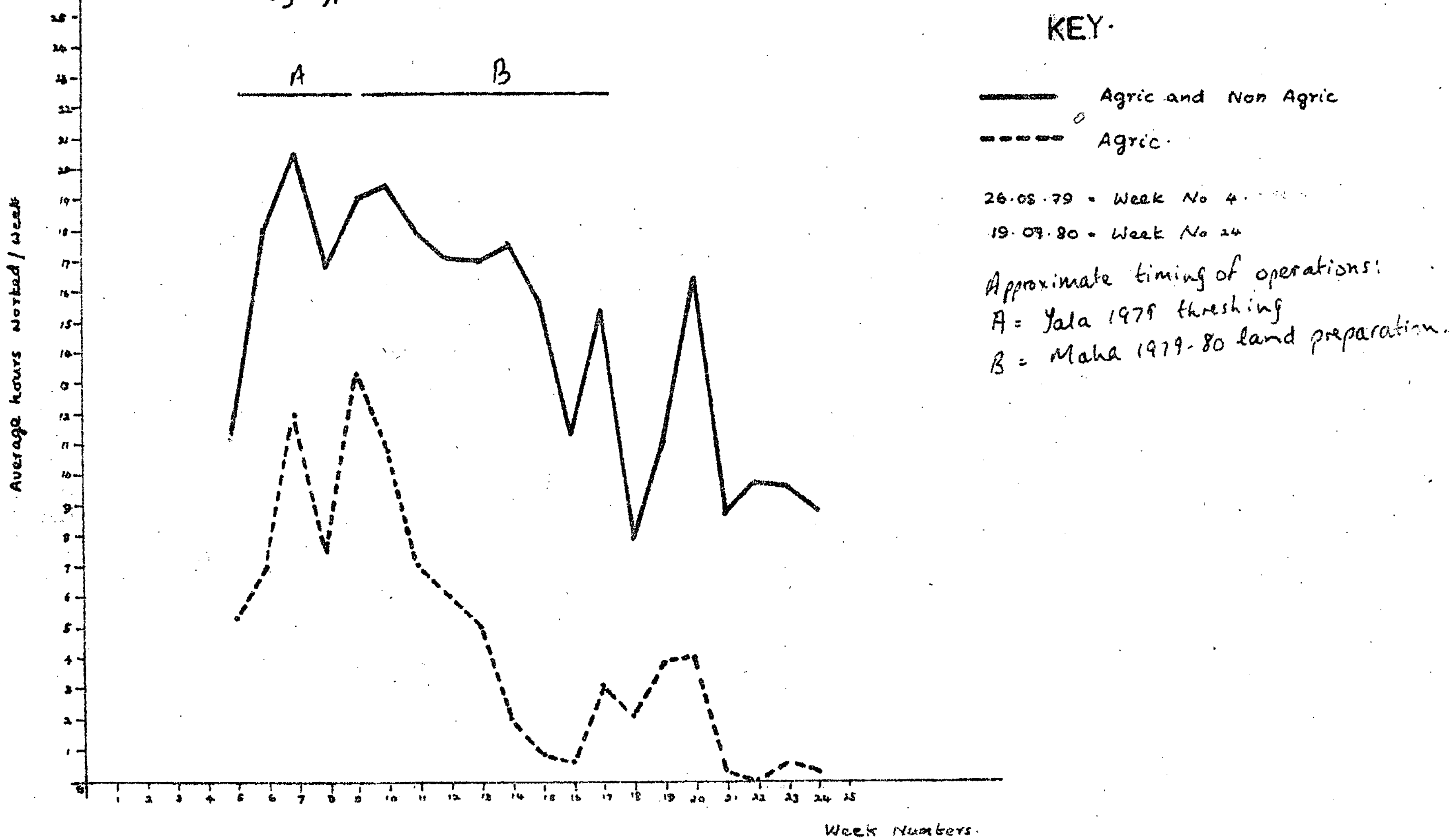
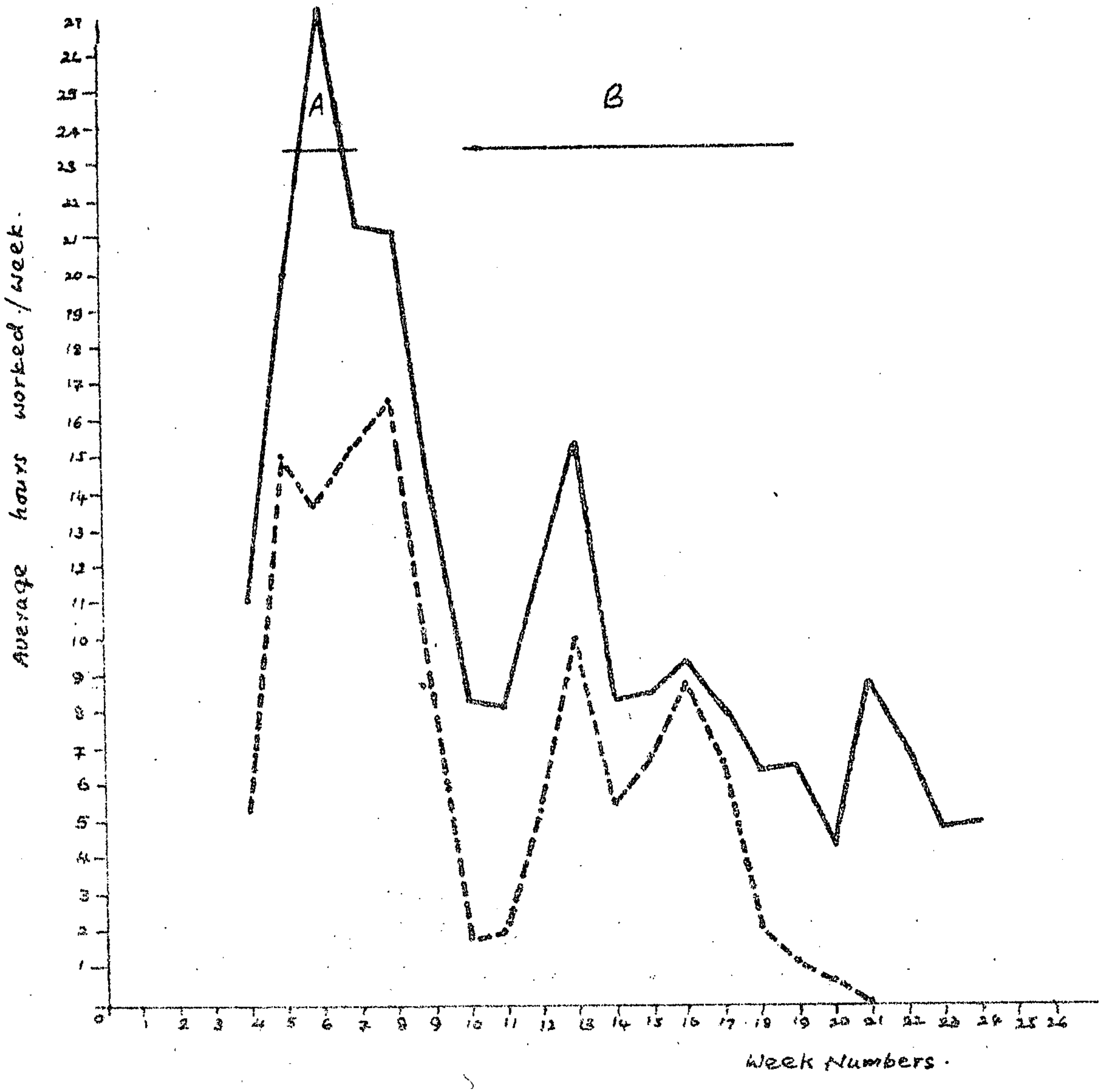


Fig 5 Average use-hours per week for 4 wt at Kavudulle - (26. 08. 79 - 10. 01. 80) by type of work



KEY

Agric and Non Agric (solid line)

Agric (dashed line)

26 . 08 . 79 = Week No 4

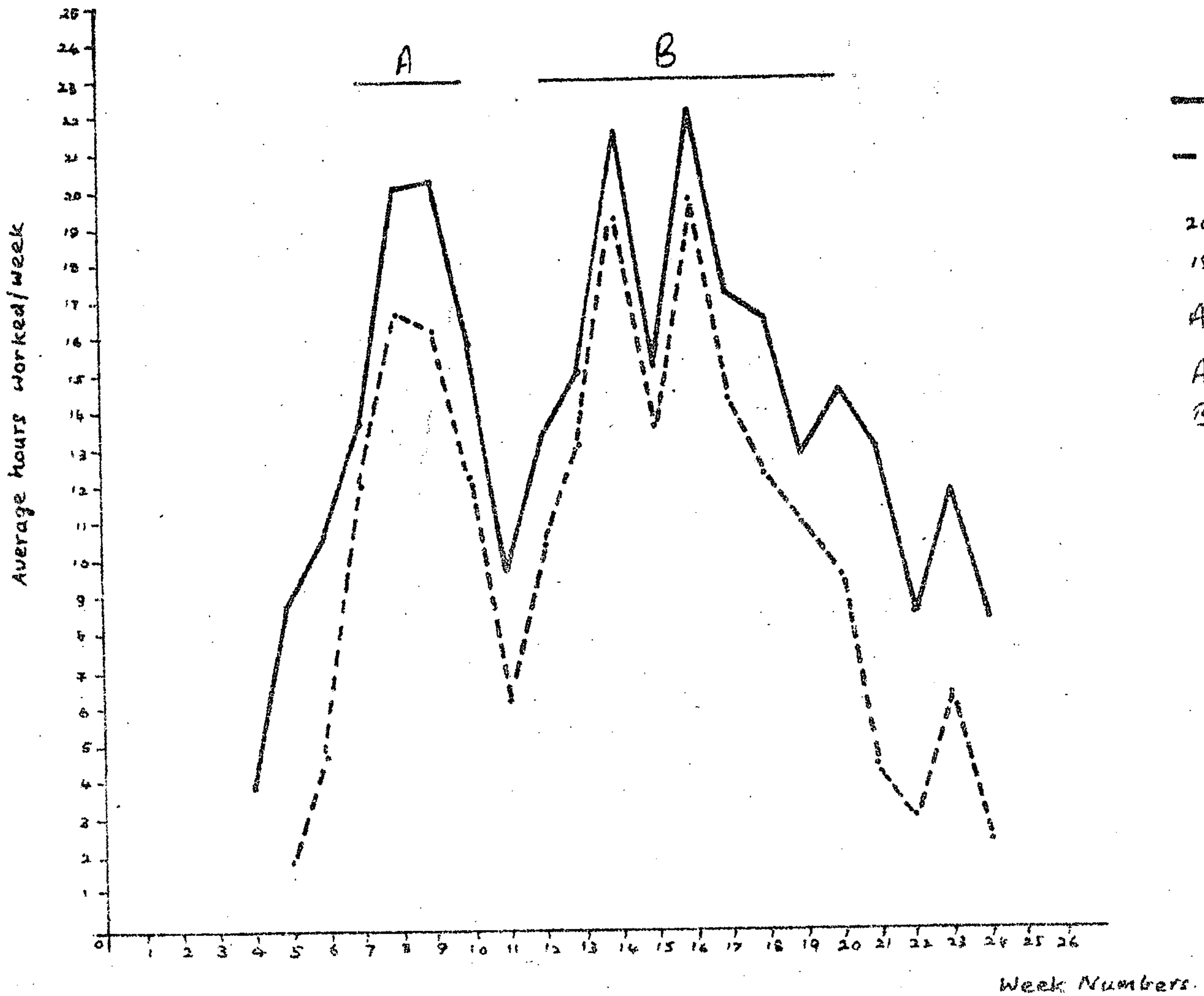
10 . 01 . 80 = Week No 24

Approximate timing of operations:

A = Yala 1979 threshing

B = Maha 1979-80 land preparation

Fig 6 Average use-hours per week for 4wt at Padaviya – (26.08.79 – 19.01.80) by type of work



KEY

Agric and Non Agric

Agric

26.08.79 = week No. 4
19.01.80 = week No 24

Approximate timing of operations:
A = Yala 1979 threshing
B = Maha 1979-80 land preparation.

Fig. 7 Average use-hours per week for 2wt at Udawalawe – (26·08·79 – 19·01·80) by type of work

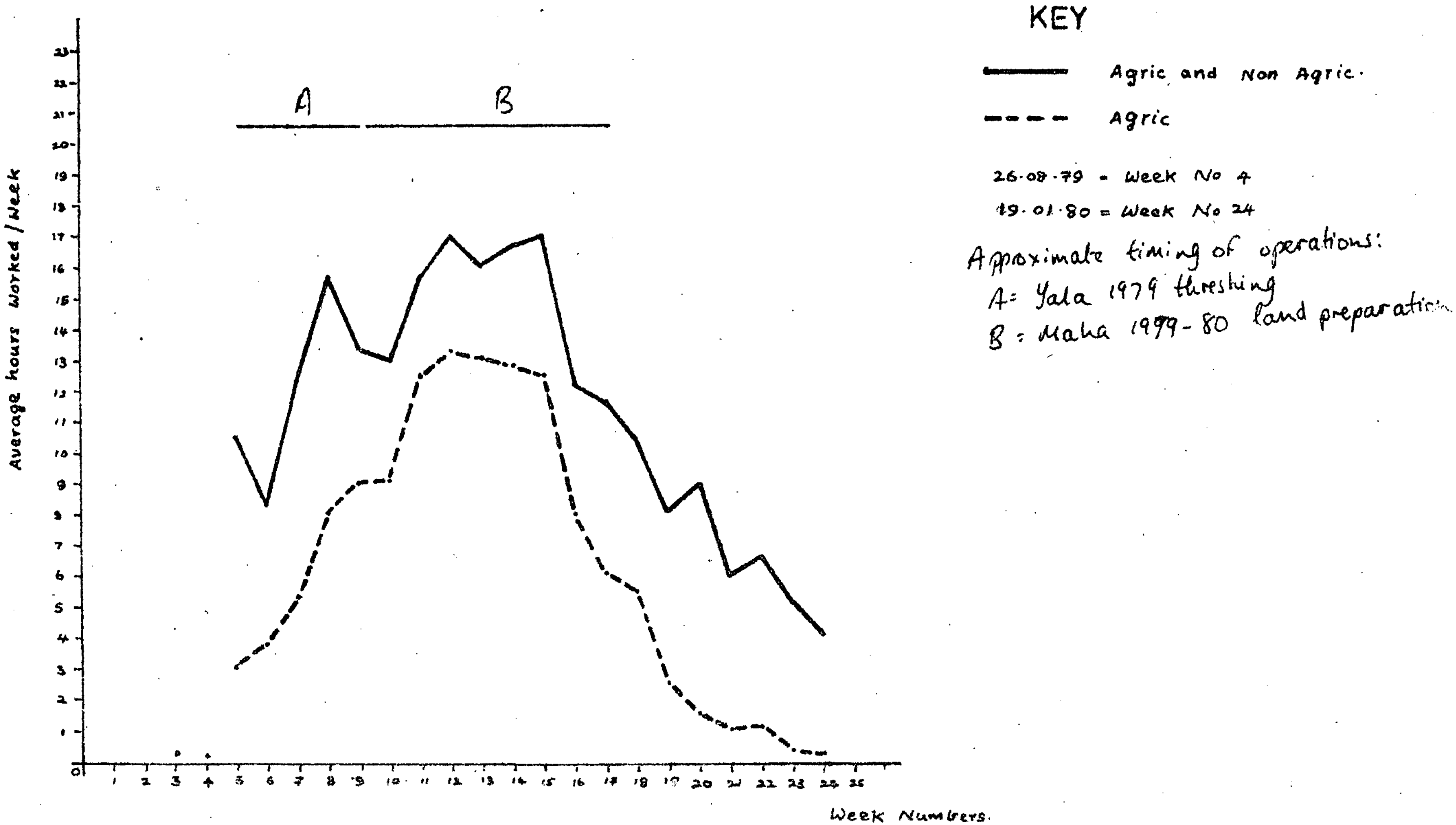


Fig. 8 Average use-hours per week for 2wt at Kavudulla — (26.08.79 – 19.01.80) by type of work

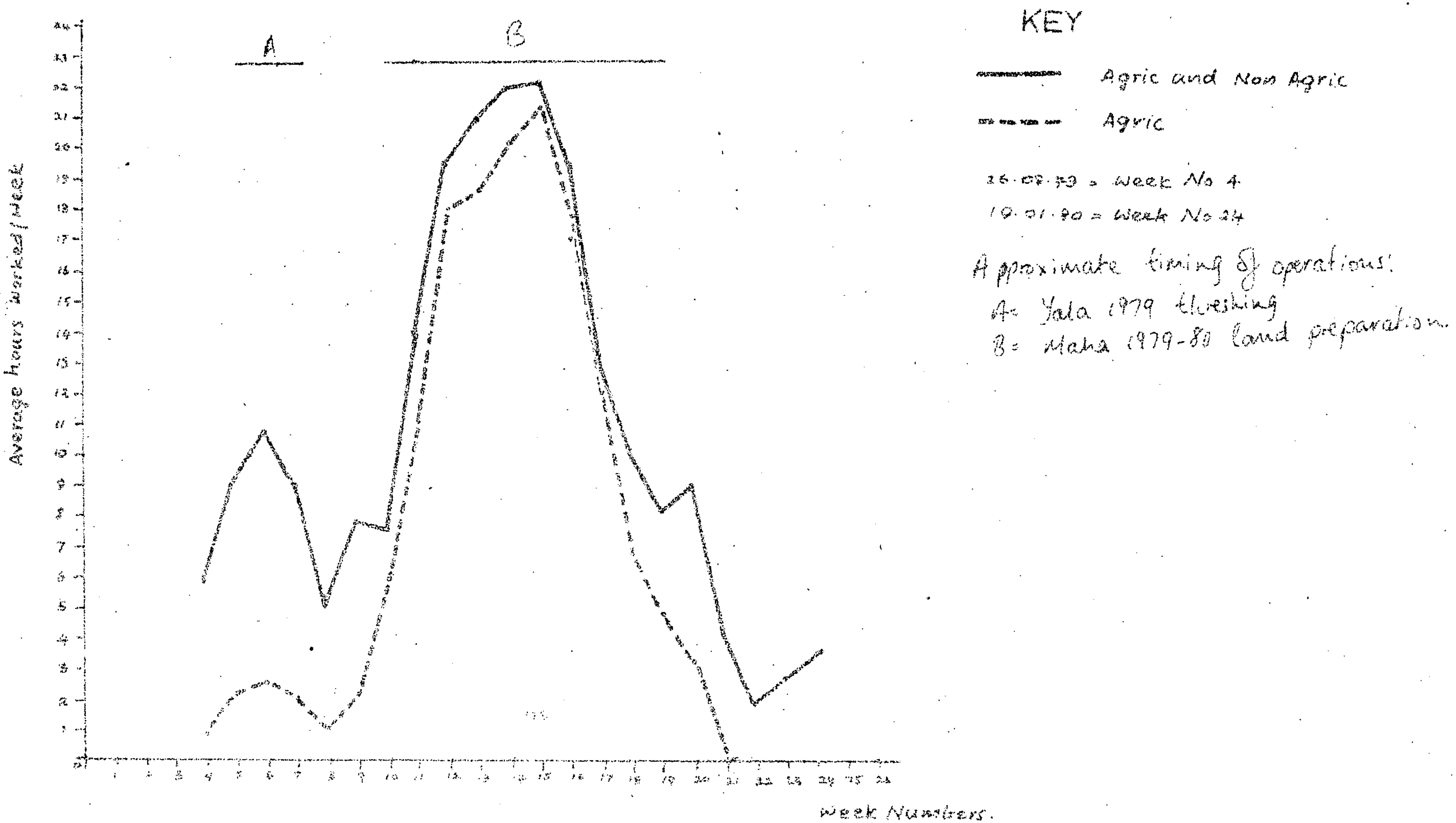
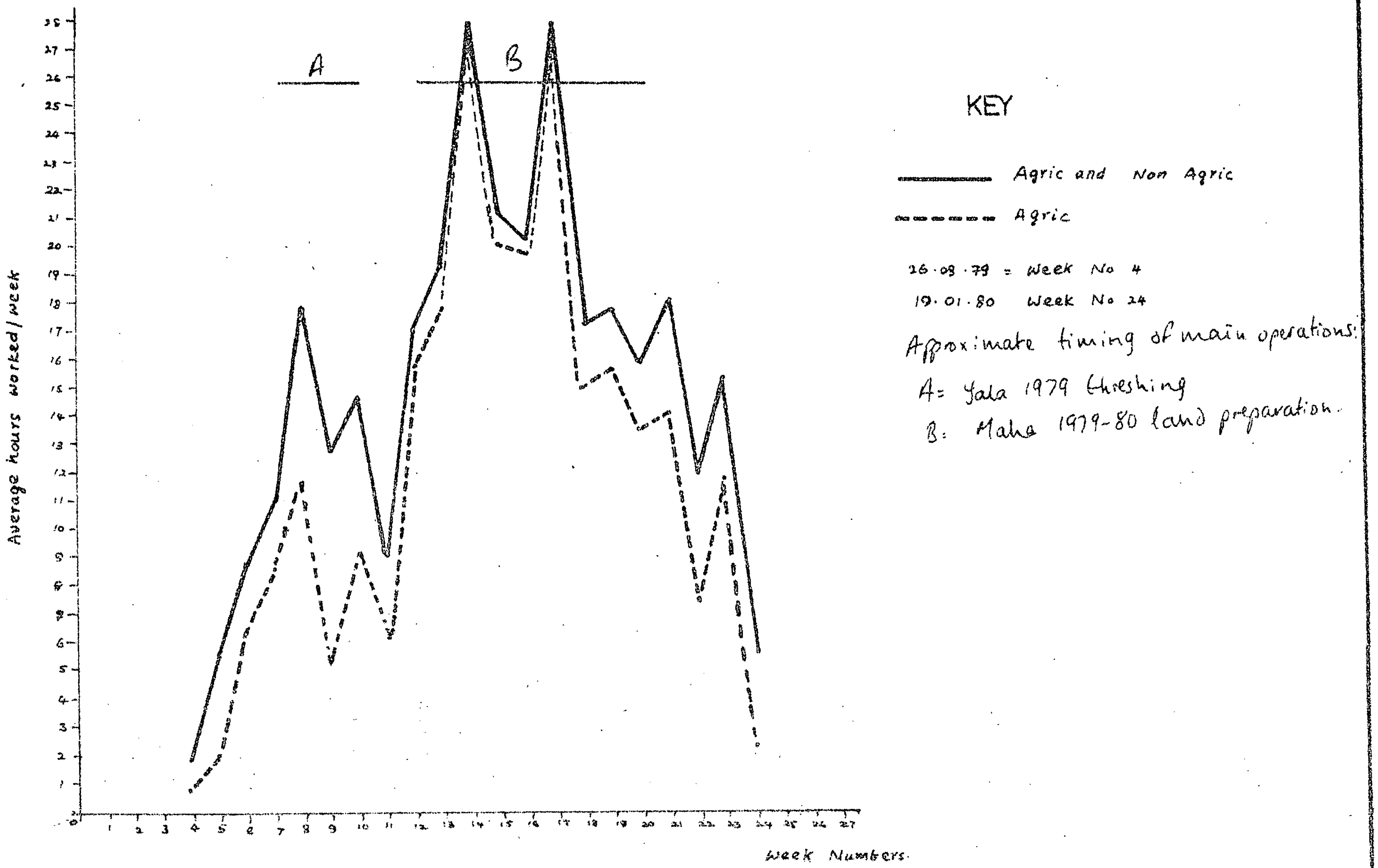


Fig. 9 Average use-hours per week for 2 wt at Padaviya — (26·08·79 — 19·01·80) by type of work



Finally, it is interesting to note that there is hardly any difference between the hiring out ratios of farmers and of businessmen. We have noted above that businessmen generally obtain higher use-levels from their power; we might conclude tentatively that their own requirements for power are also proportionally higher, permitting the same proportion of time to be allocated to contract work as for farmers.

The breakdown of contract work into agricultural and non-agricultural (Table 25) does not reveal any differences between owners and farmers that are likely to be significant, reflecting the fact that in the rural communities observed it is predominantly agricultural work which is available to both owner types, the transport opportunities at Uda Walawe (see above) being the only exception. In this connection, Padaviya, the most remote location, displays the highest involvement in agricultural contract work. Perhaps surprisingly, there seems no indication that hire-work for the 2 w.t. is more heavily biassed towards agriculture than for the 4 w.t. This is the case at Uda Walawe and Padaviya, but not at Kaudulla. The low hiring-out at Kaudulla may be generating an anomaly here. Further data might therefore permit a clearer trend to emerge.

(viii) USE-HOURS BY WEEK, FOR EACH POWER TYPE, IN AGRICULTURAL AND NON-AGRICULTURAL WORK (FIGS. 1 - 9).

In Figs. 1-3 we present a weekly breakdown of average hours worked in all operations by power type. These generally exhibit a pronounced peak of activity during a very short period (2-3 weeks) corresponding with land preparation. Whilst the peak may exceed 25 hours/week, the general level of activity over the 20 week period generally stabilises at some 10-15 hours. Week-to-week fluctuations at each location, within this broad pattern, appear to be determined largely by prevailing weather conditions.

Some differences in timing of seasons among the locations account for earlier or later onset of the peak power use. Other differences are also noticeable: whilst buffalo at all locations are confined to agricultural activity*, so that their use-pattern reflects closely the timing of land preparation, tractors are engaged in both on and off-farm work. At Padaviya and Kaudulla, where the scope for non-agricultural work is limited, (see above and figs. 5,6,8,9 below) the total use-hours show particularly high peaks, whereas at Uda Walawe, where the component of off-farm work is much higher, the tractor use-pattern is less strongly influenced by peaks of agricultural-activities. Use-patterns between on and off-farm work (analysed for tractors only; buffalo are used exclusively in agricultural work) show strong similarities for both tractor types at Padaviya and for 2 w.t. at Kaudulla. There, during the peak agricultural period, work in agriculture makes up more than 90% of total hours worked, with a much stronger representation of non-farm work before and after the peak. For 2 w.t. at Uda Walawe, more than 75% of use-hours are allocated to agricultural work in the peak period (fig.7) whereas for 4 w.t. at Kaudulla and Uda Walawe (figs. 4 & 5) the share of agricultural work at peak seasons is only some 50-60%.

These findings suggest, where 2 w.t. are concerned, that there are no grounds for fearing that the <u>potential</u> discrepancy between the high social value of farm power in farm work at peak agricultural period and the individual owner's possible indifference between farm and non-farm work actually exists in practice. The use-patterns of 4 w.t. give more cause for concern. At Padaviya, where alternative use-opportunities are in any case few, farm work is almost the sole occupation of power owners during peak seasons. On the other hand, where off-farm opportunities are more plentiful, as at Uda Walawe, non-farm work accounts for a high proportion of 4 w.t. time even at peak periods. With increasing commercialisation of newly settled agricultural areas it is possible that 4 w.t. use-patterns will shift from a pre-occupation with agriculture to a stronger component of non-farm work, even at peak agriculture periods. In this connection, Padaviya and Uda Walawe may be viewed as though at opposite ends of the "commercialisation" spectrum, with correspondingly different 4 w.t. use-patterns.

* Interestingly, this is in contrast with other countries in the present day, and with Sri Lanka in earlier times, where buffalo are (were) engaged in such operations as haulage, pumping, cereal grinding, etc. (Abeyratne, 1978). For present day Sri Lanka it reflects perhaps the availability of more profitable technologies for these alternative operations.

If this hypothesis holds true, future policy decisions on the size and composition of the farm power stock should incorporate, as a basic datum, information on the current, and likely medium-term, level of commercial activity in the areas in question. This is seen as likely to influence the availability of 4 w.t.for agricultural purposes, and will thus have implications for the size and composition of investment in farm power. At this stage in the research this is advanced as a preliminary hypothesis; further work will allow its validity to be tested more rigorously. The indications are, however, that the returns to more detailed consideration of "target" areas in farm power planning could be high.

3. To summarise the main points of evidence:

- Overall power-use levels are low, and may reflect excessively high populations in relation to the available work opportunities, but variations in use-levels among locations cannot be explained directly in terms of varying population densities.
- The bulk of tractor time (and <u>all</u> buffalo time) is used in agricultural activities, except at one location with a highly developed commercial infrastructure.
- No consistent variations in use-intensity emerge according to whether the power unit is owned at the top or bottom end of an irrigation scheme.
- Slight evidence exists that businessmen owners obtain higher use-levels than do farmers, but this will require further testing.
- "Businessmen" owners allocated 50-100% more tractor time to non-agricultural activities than did farmers.
- The proportion of use-hours spent in hire-work varies according to the average size of buffalo herd, and is much higher for 4 w.t. than 2 w.t.

3.3 National and Private Interests in Power Ownership and Use

Our earlier discussion (3.2) raised issues which now prompt a more wide-ranging consideration of whether use-patterns dictated by the private (individual) economics of power ownership and use correspond with or diverge from those which would permit maximum net national economic benefit to be derived from their ownership and use. The starting point for our discussion is the observed level and pattern of farm power use for the first part of the Maha season. As such,it is a tentative one; data still being collected might ultimately show very different use-patterns. What seems likely, however, is that use-intensity for the remainder of the 12 months survey period will be even lower than that currently observed for the Maha peak season.

The question posed is an important one, for it leads to a consideration of the acquisition and ownership of expensive productive capital as well as its use-patterns. Such capital , particularly in the form of tractors, currently represents a substantial commitment of foreign exchange for Sri Lanka. Regardless of the deeper considerations of whether the current mix of farm power is the most appropriate one for the country's needs (an issue that will be addressed in subsequent study reports), the fact remains that Sri Lanka has already committed investment to many thousands of 4 w.t. and 2 w.t. (Appendix VI), and in principle a higher return to this investment may be obtained by attempting to manipulate their use in directions other than those dictated by market forces. We shall now proceed to discuss both the effects of the market for power and the scope for obtaining higher net social returns by manipulating the market.

1) The theoretical framework

At the outset, it is important to distinguish clearly between two separate markets: that for power units and that for power time. The distinction is frequently neglected by policy makers, who tend to progress from reports (or rumours) of farmers being unable to obtain power time when they need it, to proposals that more power units should be provided (usually tractors, since buffalo cannot be reproduced in the haste generated by lack of forward planning). Separate factors govern demand and supply in each of these markets; they therefore warrant separate consideration. Only when the owner of a capital asset is also its sole user do the two markets merge. This, as evident from the high proportion of power time hired out (3.2 above) is not typically the case for Sri Lanka.

The distinctive factors governing demand and supply in the respective markets for power units and power time may be summarised as follows:

Power Units: Supply will depend on the size and age/sex composition of existing animal stocks, the fecundity ratio, calf mortality, rates of depletion for a slaughter withdrawal for breeding or milk-production, the capacity to import breeding stock and for qualitative improvements in indigenous stock, and so on. For tractors, it will depend on the capacity and (short-term) supply elasticity of indigenous production or assembly facilities (if any) and both on the capacity to import and on the world markets ability to meet such import requirements. Qualitative improvements by, for example an increase in the average horse power, are also conceivable. Finally, a possibility frequently overlooked is that of spatial mobility of power units. To some degree this is already practised in Sri Lanka,* and serves both to increase the effective number of power units available to meet the varying requirements generated by spatially staggered seasons and to increase the work-opportunities for an individual power unit.

It is self-evident that the supply elasticity of tractors, certainly in the short and medium term, will be greater than that of draught animals. Forward planning for the farm power stock, if it is not to contain a built-in bias against animal power, must therefore allow a lead-time of at least 5 years for animal populations to achieve any sizeable expansion.

The size and composition of national demand for power units will be determined by a combination of forces. It may be felt, for instance, that certain perceived requirements can be met only by a specific power type; for other requirements, power types may be in principle adequately substitutable for one another, and the respective

* Casual field observations suggest that a high proportion of the additional time made available by tractor mobility results from relatively short movements (e.g. into Padaviya from Pulmoddai and surrounding areas; and movements among the 4 adjacent schemes in Polonnaruwa). Long-distance movememts (for instance between Wet and Dry Zones) are comparatively few and tend to rely either on personal connections or on the prospect of continuous contracts (in e.g. haulage for construction purposes) of several weeks' duration.

demand for these will, in theory, depend on which type is expected to generate the highest net social returns in each of the perceived requirements.

A constraint superimposed upon this demand structure will be the overall availability of both local and foreign exchange resources. Where such resources are an active constraint, it should be anticipated that governments will scan the broad spectrum of demands on such resources both for capital and consumption purposes and allocate them in proportion to the net social benefit that they are expected to generate.

The demand for power units at the private level will follow some of the same principles: the potential private owner will, in theory, follow economic principles in allocating his resources between consumption and capital expenditure and, within his capital portfolio, will invest in competing opportunities in proportion to the net returns he anticipates from each. Specifically, with power units, he will be faced with the problems of indivisibility of capital assets (one which, for the small farmer must assume enormous proportions with this type of asset). He may also be faced with a lack of suitable alternative investment opportunities in productive assets, given his particular circumstances. These two problems are thought to be of significance in the small farmer's attitude towards power as a capital asset, and will be discussed below. Finally, the extent to which the individual potential owner of power will find his choice constrained by foreign exchange considerations will vary according to the government policies of the day. Foreign exchange may be severely rationed both by price and by quota (as under the recent Bandaranaike government in Sri Lanka), or almost freely available (as under the present government).

Power Time: This is not a homogeneous concept. The amount of effective work that can be done within a given time will vary both across and within power types, depending on their type, age and quality, the type, age and quality of implements, and so on. For practical purposes some of these differences will be small: for 4 w.t. as an example, the same implement (tine-tiller) is virtually universal. Yet some differences will remain, making power time useful as an analytical tool only if it is qualified by the specific characteristics of the power/implement/ composition.[1]

At the general level, however, it is evident that the supply of effective power time from an individual power source will depend on its mechanical reliability and the spare parts/repair facilities, the logistics of getting it to and from the work place, and, most important for the present discussion, on the individual owner's attitude towards the power source as a capital investment. This will determine how rapidly he wishes to recoup his investment outlay, and will have strong implications for the aggregate net return (i.e. net of running costs) he intends to obtain over a given time period (e.g. per annum) to permit such recoupment.

Net returns per annum are dependent on both the number of hours worked, and on the net return (or, crudely, profit) obtained per hour of use. There may be some scope for the owner to manipulate these two components without changing the total annual net return obtained. Similarly, the individual owner may have preferences (determined either by profitability or by non-economic factors) among alternative simultaneously available use-opportunities, which will constrain the supply of time to any one. In the practical context, this is particularly important in its influence on the division of power time between own and hire purposes and between agricultural and non-agricultural operations. Clearly, at an aggregate level, the supply of power time can be influenced by changes in the overall size and composition of the power stock and, for individual locations, by changes in its spatial distribution.

The demand for power time will, in aggregate, depend on the level and composition of activity in agriculture and in the construction, service,

[1] It should be noted particularly that major differences exist between buffalo use-practices at the study locations; at Kaudulla, they are used predominantly with ploughs, whereas, at Uda Walawe, they are used for trampling ("mudding") the soil. It is expected that the work rate per animal pair will vary considerably between practices. This, however, can only be analysed from data which have not yet been fully processed.

and other industries requiring power for transport purposes. For individual power types, demand will depend on their flexibility in meeting various power requirements (the demand for buffalo power, for instance, is limited to certain agricultural operations since they are not normally used in transport), and on such market and non-market conditions as relative costs to the hirer of using alternative power types, the degree of convenience they entail and the quality of work they produce.

This general discussion of the two markets supports our initial contention that it is important to keep clearly in mind the different market characteristics of, on the one hand, a capital good (power units) and on the other, a service (power time)provided by such capital. At the same time, we have suggested that there are important links between the two markets, the most significant of which, for our present discussion, is the annual rate of return which owners actually achieve, or intend to achieve, on the capital invested. We would suggest that the low overall use-levels of power recorded in our findings (3.2 above) can be better understood in the light of these economic concepts, as can the discrepancy between what is desirable or feasible in terms of use-levels for the individual owners, and what is desirable at the national level. We now make a preliminary attempt to apply this concept, preliminary in that it generates both tentative answers and further questions. Such questions can be addressed only by more detailed analysis of data still being collected.

2) An application of theory at national level

The conventional wisdom that we summarise above suggests that at both national and private levels, conflicting use-opportunities for scarce funds, both between consumption and investment, and within investment opportunitios will exist, and that funds will be allocated among such opportunities broadly in proportion to the individual net benefits anticipated from them.

This line of reasoning must be challenged in the case of farm power in Sri Lanka. First, at the national levels the power types that have most frequently been the subject of positive policy initiatives since 1945 are tractors; buffalo populations have declined by policy default, and on no occasion, to the authors' knowledge, have forward plans embracing the necessary lead-time for expanding the draught animal population been implemented. Thus, the range of options among power types which are essentially substitutable for the main agricultural operations has not been as wide as economic theory might assume, it has been deliberately restricted to 2 w.t.and 4 w.t.

Second, within this self-imposed limitation of options, the availability of foreign exchange for imports assumes overwhelming importance, since Sri Lanka does not manufacture or assemble tractors. The market for foreign exchange is for from perfect. It is not merely a case of foreign exchange availability being restricted by the capacity of exports to generate it; a major distorting factor in the form of foreign aid donors and international lending agreements has entered the market. Foreign exchange can thus be made available either completely free of direct cost to the recipient economy, or at heavily subsisted rates, by donors or by lending agreements. As our general discussion above indicates, this would tend to lead to an excessively high demand for importable investment and consumption goods, with a corresponding reduced demand in the local market. With the increasing emergence of trends in third world countries to adopt "beggar the next government" policies by over-committing themselves to foreign debts which have to be repaid only in the medium or long term, and perhaps, with an optimistic eye on the possibilities of an amnesty on foreign debt, the tendency to over spend on importables is reinforced.

The argument does not stop there, however; as Burch (1979) has already emphasised with particular reference to tractors in Sri Lanka, the spending of foreign exchange made available by aid donors is not usually left entirely to the discretion of the recipient; it is tied both to commodities and to their country of origin. Burch (1979) argues strongly that funds for the purchase of tractors have been made abundantly available on very concessionary terms by aid donors particularly when their domestic tractor industries have been going through times of depression.

Whether or not this is the case, the burden of our argument is that the demand for investment goods at the national level is strongly influenced by such non-market considerations as self-imposed option constraints and the subsidised and tied availability of foreign exchange. We must therefore expect that the rate of return anticipated from investment need be nowhere near as high as it would if the choice were based on purely commercial considerations.

The implications of this reasoning for the farm power units market at national level are clear - a bias in favour of tractor vis a vis animal power has emerged and the numbers of tractors imported may be well in excess of what would be needed to do the same work with higher average use-rates if purely commercial attitudes towards investment in tractors prevailed. Further implications for the power time market can be drawn. The situation predicted by conventional economic theory is one in which the heavy fixed cost component of a large capital asset is spread over as high a number of use hours as is compatible with its design performance (and demand conditions) within the shortest possible time after purchase, in order to recoup capital expenditures and generate surplus as quickly as possible, thereby pleasing /scarce capital funds for pressing alternative investment opportunities. The situation with resource allocation and returns to investment in farm power in Sri Lanka is vastly different: here the "pressing alternative investment opportunities" are few or non-existent. There is therefore no need to generate surplus from the investment as quickly as possible. Tractors do not need to be written off after an 8 or 10 year life as is conventionally assumed. They can be used at a much lighter rate over, say 20 years. If this doubles the national power stock requirement, then it would appear to be of little consequence: foreign exchange for twice the necessary number of tractors might easily be forthcoming from aid donors perhaps particularly from one with a depressed tractor industry.

3) An application of theory to the private power owner

We have seen that at the national level the lack of competing investment opportunities, implied both by internal restrictions of the option range and by the abundant but tied supply of foreign exchange through aid or international lending agreements, has reduced the pressure to obtain the rapid returns on capital assets that economic theory conventionally predicts. At the micro-levels of the individual owner we find a similar lack of pressure to use productive assets intensively.

Again, economic theory predicts a careful allocation of assets between consumption and investment opportunities, and within investment options. The now familiar argument suggests that investable funds are scarce, but competing opportunities many, so that the power owner will attempt to obtain high use-levels from his productive investments with a view to generating re-investable surplus. However, the purchase of farm power does not fit easily into this framework. On the one hand the range of options for heavy expenditure on consumption in the small-farm rural sector is limited. Life-styles, on the whole, are not ostentatious, even among the wealthy. Perhaps a well-constructed house with basic heavy furnishings constitutes the only single large item of consumption expenditure within the power owner's aspirations. The scope for purchase of productive investments is also limited by the potential investor's environment. On the whole, he will be a relatively wealthy, but still, by most standards, <u>small</u> farmer or a <u>small</u> businessman, living in a predominantly rural and therefore agricultural community. For the small businessman a relatively wide range of options might be available: extensions to his premises, acquisition of a new line of business, purchase of some means of transport (lorry or tractor, the latter being less expensive, and useful in agricultural work if the opportunities for transport work are limited), purchase of a paddy mill, and so on. For the small farmer who intends to continue earning a living predominantly from farming the available investment opportunities are sevely restricted. He might purchase a pumpset, but in many areas with good gravity irrigation (and this is where future policy directions lie) there might be little need for a pump (and , in any case, it is a relatively small investment. It might also be easily borrowed/hired when needed). He might purchase a paddy mill, or a small retail business, but then this is taking him outside his main livelihood activity, and there is, in any case , a clear upper limit to the density of paddy mills and retail stores that an area can support. He might become a private source of credit to those in need, but the difficulties of obtaining repayment and of securing adequate collateral are likely to limit his lending activities. The current low number of deposit accounts in rural areas suggests that he is unlikely to be anxious to earn interest from a commercial bank (though a more active advertising policy on the part of commercial banks might remedy this). We must conclude that a tractor, with a limited range of equipment, is possibly the only large productive asset towards which the small farmer might aspire. In addition to its earning potential in contract work, it confers a certain prestige on its owner;it strengthens his social position by allowing him to act as benefactor (expecting perhaps some form of reciprocation) at funerals, weddings and the multitude of other occasions when transport, however rudimentary, is required by the broader community; it removes for him the uncertainity and anxiety of having to rely on timely arrival of other contractors to do his field work. Perhaps, above all, it permits him greater flexibility in almost everything he does; it is both a productive asset and, within the norms of his social environs, a relatively conspicuous item of consumption.

If we add to this argument the fact that a tractor is a "lumpy" investment, more than one of which the farmer or businessman is unlikely to require, and that official credit schemes(e.g. TIMP, cf. Appendix III) are conventionally geared only towards tractor purchase, to the exclusion of animal power, we are presented with a situation at the individual farmer level which differs little from that suggested for the national level: the range of costly consumption and investment opportunities is severely limited, thus there is no urgency to generate rapid surplus through intensive use of a productive asset; the Sri Lankan rupee, to all intents and purposes at the small farmer level, is at present freely convertible into foreign exchange for tractor purchase; the tractor is a prestige symbol for its owner, prestige attained by its gleaming paintwork, not by being seen to have done a hard day's mud-spattered ploughing; there is a high penalty attached to breakdowns, in the form of delays in obtaining spare parts and in sub-standard repair facilities. All of these factors combine to reduce the urgency to recoup capital investments. To some degree also they are likely to reduce the use-levels of tractors, perhaps reducing particularly their availability for agricultural work, with its heavier wear and tear.

The volume and timing of tractor and animal work in alternative use-opportunities (specially, agricultural and non-agricultural uses) is a further area in which it is possible to identify potential differences between what market forces dictate and what would provide maximum net social benefit.

If a high proportion of owners prefer to use their power for non-farm purposes, even at peak agricultural seasons, and if farmers are aware of the potential negative effects on yields of the late or low quality of land preparation caused by these market shortages, they might be expected to bid up the price of ploughing services to a level which would attract adequate power time from transport into agriculture to meet the peak demand, thus equilibrating in the alternative uses the private and social ratios of values of the marginal product/marginal cost of power.

However, it is also clear that even if the predictions of economic theory are followed to this extent, there remain aspects of the timing of agricultural operations which affect the national economy and yet do not enter the market for farm power. In the context of the farming systems we are studying, one of the most important of these is the higher use of stored water which results from any staggering in land preparation. Farmers conventionally rely on a continuous flow of stored water to generate favourable conditions for mudland tillage, the effects of rainfall being largely irrelevant, or even negative if they lead to flood damage. Under present arrangements for the control of water, the period of water issue at the end of the season is almost invariably extended to accommodate those who plough and sow late, a wastage which could be avoided with a higher degree of synchronisation at land preparation. Since water is not charged on a pro rate basis, it seems unlikely that farmers will perceive water consumption as an additional cost, but it is a significant factor in national cost-benefit calculations: in most circumstances it would be possible in principle to make use of even a few days' water saving by expanding the area of irrigated cultivation, increasing the annual cropping intensity or by intensifying the cropping mix.

In practice, given the current tardiness and laxity in scheme-level decision-taking on water use(cf. 3.4 below) it seems unlikely that anything more than a fraction of this additional use-potential of water can be captured. Nonetheless, the principle is an important one: high use of tractors in off-farm work at peak agricultural periods may involve costs to the national economy which are not reflected in market prices.

We submit below a hypothetical hire charge/use-level trade-off that might face the private power owner and affect his hire customers (Appendix VIII). For the remainder of this section we discuss the possibility that, contrary to our general assertions above, certain power-owners are highly motivated to use their power intensively and to recoup invested capital as quickly as possible, but that the use-levels they achieve are held down by a number of constraints.

The particular group of power owners who might be motivated to achieve high use-levels are those who have purchased their power on medium-term credit. At present such facilities are limited to 2 w.t and 4 w.t purchase. One such credit scheme, at the TIMP; requires potential owners to raise 25% of the tractor purchase price, and the balance, in the form of a 5-year loan, is repayable at Rs.2400 per month. With such heavy repayment obligations as these, it is reasonable to hypothesise that owners who have purchased their tractors on credit are likely to use them more intensively than those who have not. With further analysis of the available data it will be possible to test this hypothesis regorously, and some policy recommendations concerning the mode of purchase of farm power may eventually arise. For the present, it is possible to discuss in general terms the constraints that a power owner might face if he does wish to use his power intensively.

These include, broadly, technical and organisational aspects. On the technical side, all of the following have been observed to some degree:

- non-availability of fuel
- non-availability of spares and repair facilities

- low efficiency of implements resulting from both design inadequacies and poor condition (esp. in the tine-tillers)
- small individual size of liyadde requiring a high proportion of turning time.

Little discussion is required on most of these points. The liyadde-size issue is an important one, since the prime function of liyaddes is to permit impounding of water and even flooding of the land. Their size is thus determined principally by topography. Whilst some experiments are in hand with long, narrow liyaddes along the contour, which would permit easier use of tractors (Davids in Mahaweli "H" - pers. comm.) there remains a basic incompatibility of scale between, especially, the 4 w.t.and the size of overall farm as allotted under recent and current Sri Lankan settlement policy and the size of fields within farms, particularly where the topography is hilly. This incompatibility forms the core of our discussions of organisational issues below.

The striking, but frequently overlooked, incompatibility between the technical capacity of particularly the 4 w.t.and the average size of paddy holding (2-3 acres in current settlement plans) makes it necessary for the tractor owner seeking hire-work to arrange two or three sequential contracts per day. In the study locations there appears to be no clear pattern of individual power owners hiring to a number of farmers with contiguous lands. This implies they must incur a substantial loss of time in arranging contracts, and in travelling between farms. Experiments are under way at the TIMP(Russell, pers. comm.) to attempt to assess the time saving attributable to more systematic organisation of hire contracts. Whilst such work may help to quantify the time-losses incurred, it seems unlikely that policy makers can do anything to achieve more systematic ordering of hire-work in such an essentially free market within the present context of simultaneous timing of cultivation. Preliminary suggestions in favour of organised staggering (Farrington & Abeysekera, 1979; section 3.4 below) might, however, by focussing owners' attention on the urgency of arranging hire-work,have the added benefit of facilitating pre-arranged hire contracts in both first and subsequent areas to receive water.

Our discussion in this section, in an application of economic investment theory, attempts to account for part of the observed low use-rates of farm power in terms of lack of investment opportunities at both national and private levels available to compete for the funds tied up in power, particularly in tractors. There seems to be no discrepancy between what use-levels are currently perceived as necessary at national and private levels. Even if it were possible to raise policy makers' expectations of power use-intensities to levels more compatible with the international opportunity cost of capital, there is no guarantee that such expectations would or could be incorporated into the private owners' decision - taking framework, given present low opportunity costs of potential investment capital at individual level. Credit purchase schemes might offer scope for higher use-intensities, but this remains to be tested against the data. A priori many constraints militating against such higher use-intensity can be perceived.

3.4 Relevant issues in the control and use of water[1]

The concerns of the study with water use and management may be summarised under three main headings:

1. The study of the technical, social and economic interactions between farm power use and water use.
2. The search for more efficient and equitable combinations of farm power and water use.
3. The development of a range of likely medium-term scenarios of power and water use for major irrigation schemes, projections for both elements, separately and in combination, involving consideration of the trade-off between technical or economic efficiency and administrative/technical feasibility.

Information relating specifically to water management has been collected in the three following ways during the Maha season:

1. The sociology questionnaire administered to all sample farmers

[1] This section is attributable to M.P.Moore, IDS, Sussex University, Consultant to the study team in Water Management.

and owners towards the end of the season includes a three page section designed to elicit 'information about cultivators' water problems, their attitudes to water management and the way in which water is used by farmers, their preferences for water management systems, and the means they use to obtain additional water. Although the answers give rise to the problems of interpretation necessarily connected with subjective and open-ended questions, the exercise proved valuable, and a useful means of alerting the field investigators to the questions with which the study is concerned. Field investigators have been able to supply much useful supplementary information. The data given in the questionnaire have not yet been tabulated.

2. Investigators have filled in a weekly schedule for each farmer which indicates whether or not water was available in his or her field channel. Because relatively abundant irrigation water has been provided on all schemes this Maha season few problems of water scarcity have been encountered.

3. The water management consultant spent several days in each of the three study schemes in February - April 1980, pursuing the questions raised in the water management schedule and investigating the way in which water is managed at the level of the scheme as a whole. Combined with information obtained from reports and interviews with officials and technical experts in Sri Lanka and the U.K., this information is being used to develop scenarios about likely possible changes in water management in the medium term.

These scenarios are all premised on the observation that water flows in irrigation schemes have a high degree of automaticity, are tightly constrained by physical and institutional factors, and are in fact amenable to only limited outside control or reform. Our evidence for this lies in the decisions which are made about water management.

The management <u>decisions</u> which are made each season fall into very separate categories, and are mainly made by different people in very different contexts. The first set are the decisions of the seasonal Water Meeting about the extent and location of land to be cultivated in the coming season, cropping patterns, timing, and the system of rotations, if any, to be pursued. In fact, these decisions are mainly determined by physical factors, above all the level of water in the tank and the timing of the harvest of the previous seasons' crop. When water supplies are expected to be adequate the long standing preference for paddy asserts itself and the possibilities of alternative cropping patterns are largely ignored. The incentive to experiment with more water-sparing crops exists only where water is scarce. Physical factors mainly determine cropping patterns, varieties, season duration and timing, and the rotations to be pursued, if any.

If less than the total area is to be cropped, then the layout of the channel system mainly determines which areas are to be supplied with water and which not. These are areas of land which can be supplied with the lowest conveyance losses and the minimum likelihood of illegal appropriation of water by cultivators whose lands are not scheduled to receive water. In effect water must be provided at tracts near the top of the total system and / or the top-ends of tracts. Decisions are further constrained by the need to obtain the support of the farmers present.

The second set of decisions are about the day-to-day implementation of the water delivery schedule decided upon at the Water Meeting. On occasion a major change in circumstances may lead the Irrigation Engineer to amend the decisions - to change the rotation, delay the opening of the sluice in the event of heavy rain, or extend the period of water release. In addition dozens of decisions are taken daily about the detailed implementation of the schedule: whether to close this gate in the morning or evening; whether to bother to repair that leaking gate or break in the canal bund; whether to try to stop this farmer from pumping or siphoning water from the channel; whether to extend or increase the issue of water to this field channel because the tail end farmers complain that water has not reached them yet. The scope for choice in making these routine decisions is however severely constrained by a very deeply-rooted and unyielding combination of physical and social variables. It is in fact the attempt to mitigate the worst consequences of this combination which constitutes the object of most of the routine decisions about water. The following are the main elements entering into this combination:

1. The economic and political circumstances surrounding the design and construction of Sri Lankas' irrigation schemes.. Fundamental has been the ideological and political aim of re-populating the lands of the Sinhalese kings and relieving land hunger in densely-populated areas. It has been necessary to be seen to settle as many people as possible given available funds, where 'settle' means providing housing and social and economic infrastructure as well as land. Irrigation systems had to be constructed as cheaply as possible per unit of land'commanded', while at the same time appearing to provide fully for the needs of each settler. In terms of irrigation lay-out this meant a comprehensive channel system intended to supply each farm individually from field channels, while at the same time saving money by economising on channel density per unit of land commonded. This result was systems with very long D-channels and field channels, and no (because costly) system of re-use of drainage water.

2. The historical traditions of the Irrigation Department. From the beginning this has been staffed at the professional level entirely by civil engineers (not agricultural engineers) and concerned almost entirely with investigatinn, design and construction, i.e. civil engineering aspects of irrigation. Irrigation engineers did not become more deeply involved in water distribution than decisions about opening and closing main sluices from the tanks. The delivery of water to farms and involvement in the related human relationships - individual problems, disputes, prosecution of irrigation offenders etc., - was the province of a range of other government agencies and officers. Thus the considerations involved in actually managing irrigation systems did not impinge deeply on irrigation design. It was only in the 1950s and 1960s, when the Irrigation Department began to get more deeply involved in operations, that it became fully aware of the problems created by its own designs, and attempted to introduce new ones. The new standard design incorporates smaller areas commanded by individual field channels ("turnout areas"), averaging around 40 acres

and served by standard 1 cusec field channels.

3. The absence of a dense and disciplined network of field staff able to enforce regulations and deny water to farmers who are able to obtain more than their designed quota.

This combination of physical and institutional factors combine with others to cause the 'top-ender - tail-ender' problem. It is extremely difficult to make water reach the tail-ends of distributary and field channels. The design layout, involving long channels, makes this extremely difficult, for all the way along the channel farmers are able to take more than their designed quota of water by breaking bunds, damming channels, siphoning and pumping. Inadequate water reaches the tail-ends. The obstacles are physical although man-made. They could in principle be overcome, but only with a dense and disciplined administrative apparatus able to intervene and direct water down at the field channel level and prevent the practices by which farmers near the channels obtain more water than intended by designers. At present the 'top-ender - tail-ender' problem cannot be tackled in this way. Part of the reason is the lack of incentive provided by the fact that the more rich and powerful, including tractor owners, tend to be top-enders. It is not clear how far richer and more powerful people are able to obtain prime top-end plots in the process of initial settlement. However, the greater productivity of top-end plots soon makes their owners more wealthy than tail-enders, especially when, as at Padaviya and Kaudulla, the later-settled tail-enders received smaller allotments than top-enders.

The systems do not serve tail-end farmers in the way intended. Many simply do not receive water through the field channel, but depend on the use interruption of drainage water, either from the drains themselves from other farmers' fields. It is very difficult to get water to 'tail-enders', for the appropriation of water is determined mainly by the location of fields vis a vis the source of water. The pattern of intra-farmer water distribution is to a large extent fixed, and beyond managerial control. It includes informal arrangements among farmers to pass water to one another by inter-field flows.

It is the tightness of these physical/institutional constraints which explains why experiments to date with elected farmer representatives have had little success. Elected farmers have no authority, legal or actual, to deprive top-enders of water and ensure that it is sent to tail-ends. Tail-end farmers can make their own arrangements to get water from other farmers by field-to-field flow if such a thing is technically possible at all. More importantly, it is not at the field channel level that the problem lies. Water is appropriated by farmers near the main channel and the top of D-channels. Tail-end field channels simply get inadequate water, so the attempt to share that out more equally is misconceived. The need is for more water from the upper reaches of the system. Farmer representatives at the field channel level may be able to ensure better maintenance of channels, and this will be useful. There is however little reason to expect that the 'Vel Vidanes' now being elected or the local irrigation associations (Jala Sampath Palaka Sabhawa) proposed under the draft new Irrigation Ordinance will have a major impact on the water management problem.

Our questionnaires showed that farmers almost universaly go to see an official of the Irrigation Department/RVDB if they have a water problem and have some reasonable expectation that something can be done about it. In many cases they do not bother because they know that there will be no result. There have however emerged interesting differences between the study schemes in the level at which farmers contact officials. In the Kaudulla scheme the key persons are the three Work Supervisors, all of them experienced men long acquainted with the scheme. They appear to exercise a fairly high degree of control over their subordinate maintenance labourers, who actually open and close the gates to D-channels and field channels. At the same time , Work Supervisors know a great deal more about the scheme than the Technical Assistants and Engineers above them, for these superior officers are transferred regularly and do not stay long enough to become familiar with the local scene. They are happy to leave as many water management decisions as possible in the hands of works supervisors. In Padaviya, by contrast, control of water on a day to day basis is less concentrated in the hands of Works Supervisors. Both the maintenance labourers below them and the Technical Assistants above them appear to play a greater role. There appear to be a number of reasons for this, including: the general laxness of control and supervision found in all governmnt departments there due to the 'punishment' nature of posts there; the existence of a rotational schedule in all paddy seasons; and the fact that some Technical Assistants have been in post there for a long time.

It was found that relationships between irrigation officers and farmers seemed to vary considerably, with a marked contract between farmers at the top-ends and tail-ends of the channel. The former, generally receiving more water and thus having fewer problems, appeared more likely to express general satisfaction with the present water management system.

Tail-enders were quite naturally more likely to express dissatisfaction, and this often took the form of criticism directed at officials. While much of this criticism is no doubt justified, allegations that officers were engaged in the corrupt distribution of water are probaly unjustified. Such allegations come almost entirely from tail-enders. They are rejected mainly because of inherent implausibility. It is very difficult to supply water to individual farmers, since in most cases one must provide water to a whole field channel. It is unlikely that an individual would pay to benefit all his neighbours, and there was no sign of collective bribery. Further investigations and the tabulatinn of responses to questionnaires will no doubt throw more light on the relationships between farmers and officials, but the interim conclusion is that officials are not to any important extent under the influence of bribes, wealthy men or tractor owners in distributing water among channels. The wealthier people, including tractor owners and resident officials, tend to have a better supply of water, but mainly by virtue of cultivating land at top ends of systems and / or being able to afford pumps to obtain water directly from channels.

Changes in the way in which water is distributed can only come slowly, because they must contend with strongly rooted interactions between physical and institutional factors. Two proposals for desirable and relatively easily-achievable change have however been identified, both of them having implications for more efficient farm power use:

1. The deliberate and planned staggering of seasons between the two main canals of each scheme. Were one part of the scheme issued with water two or three weeks before the other, then tractors and buffaloes could be shifted from one side to another their period of use extended, and capital costs recouped over a shorter period. Very low overall rates of power use have emerged from the data collected so far.(See above) The principle of planned staggering of seasons could be extended to cover distributory channels feeding off the same main channel. This would however require substantial improvements in infrastructure and changes in management practices(see below). Staggering between main channels requires only a small change in practices, since control would be exercised at the headworks sluice.

2. The improvement of the mechanism for planning water issues at the tank level. The present system of seasonal Water Meetings held just before the season commences is inadequate for three main reasons. The first is that it invests most initiative and authority in senior officials, especially the Government Agent and the Irrigation Engineer, who are transferred so regularly that they have little knowledge of individual schemes' reservoir of past experience to draw on. This reservoir of experience exists among more junior officials and farmers. The second is that inadequate time is given to plan the future season and obtain the necessary seed, credit, etc. The support services for paddy are generally well-established, and so it is not seriously affected by such delays, but for other crops which are potentially attractive particularly in times of scarce Yala water supply, the lack of forward planning together with poor existing input supply and marketing services, militates heavily against their cultivation. Some of these crops, especially chillies, perhaps the most profitable, are long duration crops. Advance warning is required of a decision to issue water adequate only for non-paddy crops in Yala. Nurseries must be prepared, seeds procured by the agricultural official or private traders, and credit must be obtained for the relatively higher per acre cultivation costs. The third problem with the

present arrangement is that there is only one meeting, and there is no acceptable way of getting agreement among farmers for modifying decisions in the light of changed circumstances, especially water availability different than expected. Irrigation Engineers do often amend the decisions on their own initiative, but this creates resentment among farmers who have already voted to accept a different decision.

Precisely how the present system should be amended will be the subject of further investigations, focussing especially on the experience of elected Tank Committees of the five schemes falling under the Tank Irrigation Modernisation Project.

Apart from the analysis of the questionnaire data already collected, the main ongoing/planned work in the field of water use comprises:

1. The study of Tank Committees (Appendix III, Annexe).
2. The appointment of a Water Management Investigator for the Kaudulla scheme for the 1980 Yala season in order to collect more detailed and comprehensive data on the factors affecting water distribution.
3. A survey of sample farmers in order to discover the relative importance of channels and field-to-field flow in the supply of water, especially to tail-enders.
4. The development of a range of scenarios reflecting likely and possible future changes in water management on large scale schemes.

SOCIOLOGICAL INVESTIGATIONS

The Sociological Investigations seek to complement the main economic study in its data and methodology and to provide a kind of interpretative background for the largely quantitative data collected in the main study.

The team involved in the sociological investigations consists of six investigators, two at each study location, and two research officers, one responsible for work relating to Padaviya and Kaudulla and the other responsible for Uda Walawe. The investigators reside on locations while the research officers make periodic visits. The investigators are all graduates in the Arts stream but not necessarily acquainted with social/anthropological methods and concepts. However, they were sufficiently informed about the nature and objectives of the study and its methodology through long and repeated discussions before going to the field as well during field work.

The field work may be divided into three distinct phases:

1) collection of general background data and establishing rapport;
2) the questionnaire survey; and
3) probing into specific issues.

During the first phase, lasting for about two months, the major concern was to get to know and be known to the people in the study locations. Attempts were made at this stage to collect information on general social and economic conditions, historical background of the places etc., and to identify important groups and individuals. Records were kept of the discussions and observations of the investigators in "field logs". The "field log" is a diary of all significant discussions, observations and activities of the investigator in the field. In the writing of the field log, a uniform format was adopted by all investigators to facilitate cataloguing and indexing for more effective use in subsequent analysis.

The questionnaire survey was designed to provide quantifiable data relating to sociological, economic and water management issues. It contained closed and open-ended questions on a wide range of topics, as detailed above (pp. 32-33).

The third phase, currently underway, is judged the most important stage of the investigations. This phase coincides more or less with the full length of the 1980 Yala season in all three locations. Armed with sufficient background information on people, places and general conditions relating to farm power and water use current work will focus on the collection of specific and detailed data.

Although the tabulation of data in the sociological questionnaire is still underway, the field observations and the information gathered from informal discussions with many farmers, farm power owners and various public officers in the field by the sociology investigators and the researchers themselves reveal some interesting sociological issues relating to power ownership, the choice and the use of power types, management of farm power, credit, consumption patterns and the network of social relationships of farmers and farm power owners. These are discussed in a preliminary fashion below:

FARM POWER OWNERSHIP

Our preliminary observations show that tractor ownership is concentrated in the hands of a few affluent farmers, businessmen and those who have access to sources of income other than from farming. Among the allottees, those who were in a position to invest in tractors were the ones who managed to cultivate more paddy acreage than their normal allotment. The pattern shows that the top-end farmers had more opportunities to invest in tractors. At Padaviya the farmers who were able to obtain bank loans to purchase tractors under the Tank Irrigation Modernization project, were the ones who could raise sufficient funds to make the down payment. This came to a substantial amount (in excess of Rs.10,000) when they purchased four-wheel tractors. Thus our preliminary observations show that most of the tractor owners in all the study locations were those who had a surplus of income accumulated through business, contract work, working as co-operative managers or were affluent farmers who were in a position to cultivate leased or rented land. Furthermore, it appears that those who had large herds of buffaloes were also able to sell part of their stock to invest in tractors.

The buffalo-ownership pattern shows that both at Padaviya and Uda Walawe large herds were concentrated in a few hands while at Kaudulla, where farmers commonly keep a pair or two, feeding them from the homestead allotment, ownership was widespread. The practice seems to be something that these farmers brought with them from their places of origin. Most of these farmers are from Kandy, Kegalle and Kurunegala Districts where this practice is widespread. The limited availability of grazing land is common to all three locations but, at Kaudulla, it had become a more serious problem which would have prevented the growth of large individually-owned herds as in the other two locations. Both at Uda Walawe and Padaviya, herds of buffaloes are taken to distant places for grazing after the cultivation season.

The general picture shows that there is a gap-economic and social-between farm power owners and farmers who do not own any type of farm power. This gap is all the wider when non-owners of power are compared with tractor owners, especially with owners of four-wheel tractors. The tractor owners are in a more powerful position than the non-power owners, both economically and socially. The latter frequently have to depend on the farm power owners not only for their power requirements but also for other facilities such as credit. Although they differ considerably in power position, sophistication and degree of solidarity, the farm power owners and farmers without power resources are interdependent specifically through the power hire market and more generally as members of a single local agrarian system.

LAND TENURE AND FARM POWER OWNERSHIP

Preliminary observations show that there is a close relationship between farm power ownership and land use or ownership. Although land laws governing the colonization schemes prevent sale, lease or mortgage of land allotted to colonists, these practices are widespread in all study locations. Most of the sample farm power owners have been able to invest in additional paddy land, and have the necessary farm power to cultivate large extents of such land. Informal discussions with colonists show that some farm power owners cultivate large additional acreages of land rented out or leased out from other colonists. Furthermore, when paddy land is reallocated under <u>bethma</u> arrangements during Yala when there is not sufficient water in the tank to cultivate the entire command area, farmers who are allotted fields far away from their homes prefer to rent them out. The power owners take this opportunity to rent in such land from different farmers. A particular advantage is placed in the hands of power owners when decisions on the details of bethma cultivation are delayed, as at Kaudulla in Yala 1980. In these circumstances those at the top end who own or have easy access to power often plough their entire holding before it can be subdivided, and those designated eventually to share, rather than pay for a ploughing in which they have not participated, are tempted to relinquish their portion of the land against a share of the crop or cash rental, and to earn a living by casual labour. In these circumstances the bethma system instead of promoting equity, as it is widely held, achieves precisely the opposite to what is intended.

Furthermore, even during the Maha season when all the land in the scheme is cultivated, those farmers who are unable to meet current cultivation expenses or who were unable to repay previous loans frequently rent out land to those who supply them with credit facilities. Here again, affluent farmers, businessmen and some public servants make use of the opportunity to lease land from credit-short farmers. According to farmers, those who own farm power are in a better position to cultivate additional land. At the same time farm power owners contract with the cash-short farmers to plough their paddy fields in return for a share of the crop. Our interviews suggest that power owners get much more profit in such a situation than when they perform custom services for cash.

Our informal discussions in the field suggest that ordinary farmers are gradually losing operational control of their paddy fields and that power owners are increasing theirs. These two phenomena may be related components of a single process. Data currently being processed may add quantitative substance to these preliminary observations. They may also permit closer examination of any causal linkages.

FARM POWER USE PATTERN

Although informal discussions at the study locations suggests that the bulk of land preparation is done by tractor, the opinion common among farmers is that draught animals give a higher quality of land preparation. Farmers say that the levelling of a <u>Liyadde</u>, which is essential for better irrigation, is easy and less labour demanding when buffaloes are used. Although ploughing itself takes less time with tractors, it appears that when there is a heavy demand for tractors farmers have to wait a long time to hire one. Often they have to pay hire charges in advance but leave the work schedule of the tractor to the convenience of its owner. When the majority of farm power owners are involved in the preparation of their own land, non-owners are unable to obtain custom services at the exact time when they are needed. Thus although farmers reported that most of them use traetors for timely preparation of land in order to be within the planting time schedule, it would be interesting to calculate the waiting time for the arrival of tractors and compare it with the time which owners of draught animals take to prepare their fields starting immediately after the water issue. The increase in tractor hire charges, the long waiting time for tractors, and the poor quality of land preparation, would all at first sight appear compelling grounds for farmers to turn to animal traction if it were easily available. Whether such a reversion to animal power might in fact be forthcoming is an issue of central importance to policy and will be investigated in a subsequent phase of this study.

Although our respondents reported an increase in hire charges for buffaloes in line with increased charges for tractors,(cf. also Farrington & Abeysekera 1979), there are differences in the arrangements for payment. Normally tractor owners expect farmers to settle their tractor charges in advance or immediately after the custom service is performed. However, farmers who hire buffaloes reported that customers could come to an agreement with the owners to settle their payments after the harvest. According to farmers, this latter is convenient for them expecially when they are unable to raise the necessary agricultural credit. Furthermore, some reported that buffalo owners sometimes write off their charges when there is a crop failure. However, when either tractor or buffalo owners enter into a contract with farmers to plough the land on a crop-share basis, the value of payments is higher than when cash is paid at the time of the custom service.

Among the reasons given by farmers for the use of tractors for land preparation, the most common one is their need to finish the job within the time schedule. From our preliminary observation it appears that the arguments such as that tractor use would lighten the physical burden of farm work, increase farmers' leisure time, release labour for alternative employment, attract educated youth for farm work, do not seem to be strong in the study locations. Whether the apparent insignificance of these reasons, particularly the first two, can be accepted at face value remains an open question. It is conceivable, for instance, that with the advent of tractors, farmers' attitudes towards work and leisure have shifted gradually over time, and that at least some farmers now regard the effort necessary to complete a full cultivation with animals as unacceptable. This possibility clearly merits further consideration.

MANAGEMENT OF POWER UNITS

The proper management of tractors depends on the availability of spare parts, fuel and service facilities. The sociology questionnaire is designed to elicit quantitative information on the adequacy of existing services, and this is currently being analysed.

The management and maintenance of draught animals even when they are not in use is a complex exercise. Looking after the animals throughout the year involves additional labour. According to farmers, grazing has become a serious problem in all locations. The lands reserved for grazing in the original settlement plan have been encroached for cultivation. During Maha season, when there is sufficient water, even road reservations are used for cultivation. The lack of grazing facilities in these schemes has become a severe constraint in the development of livestock herds.

Many farmers reported that they do not want to keep buffaloes in view of the problem of grazing facilities. Buffalo owners have to engage persons to look after the animals througout the year. Some owners hire people who take the animals to far away places for grazing. Buffalo theft has become a serious problem in the study areas and it discourages farmers from raising livestock. On the other hand, the tending of livestock may provide employment opportunities in the off-season for labour which would otherwise be unemployed.

Another aspect of livestock development is the possibility of combining milk production with the production of animals for draught power. Both at Padaviya and Kaudulla buffalo owners do not produce any milk or curd for sale . Even at Udawalawe, where there are some buffalo owners who produce milk and curd for market, it is not a practice which is widespread. Buffalo owners who are interested in producing milk and curd felt that they would be unable to sell it.

One of the current objectives of the study will be to examine the constraints to production and sale of animal byproducts and to assess their impact on the economics of animal husbandry.

The involvement of farmers in conflicts with fellow settlers as a result of crop damage by buffaloes is common in all the locations. With limited grazing facilities and when most of the land in the scheme is under crops, it has become an extremely difficult task to look after the animals without trespassing into another's allotment, with inevitable damage to crops.

According to many farmers and buffalo-owners this is one of the serious constraints to the development of livestock in the settlement schemes. The arrangements made for settlement of such conflicts are also not very satisfactory in most cases, and therefore, there are occasions when both parties, the owners of buffaloes and the farmers whose crops were damaged, face problems in resolving such conflicts. This is another interesting issue which would need further investigation. Initial impressions suggest that the tethering and stallfeeding method practised at Kaudulla has led to fewer incidents of this type than occur under the conventional Dry Zone herding methods practised elsewhere.

CREDIT FACILITIES

Credit is one of the issues which need probing into in the present study, because it is partly related to farm power needs of farmers and the ownership of farm power. Those farmers who need short-term and long-term credit for both production and consumption purposes, have to depend mostly on non-institutional credit. The majority of farmers disclosed that they are unable to get agricultural loans from banks because of various disqualifications. Even those few farmers who get such loans have to turn to other sources for credit for consumption. When taken from private sources, the interest rates are very high, and often farmers have to give security for such loans. The most common practice is to make use of their paddy allotment for this purpose. Here again farm power owners and other wealthy farmers or businessmen make use of this opportunity to lease or rent in land by extending credit to needy farmers.

Another interesting related feature that is quite conspicious at the study locations is the pattern of spending of these settlers during and after harvest time. There does not seem to be a rational plan of expenditure and spending is lavish during the harvesting season. The consumption pattern shows that there is a rise in such expenditure immediately after the harvest, followed by a fall during non-income months. The middlemen advance money for production, consumption and for ceremonies and at any unexpected but urgent need. The loans are often given on mortgage or security of land and some farmers find it difficult to settle these loans for many years. Informal discussions suggest that more than a high proportion of the settlers are caught up in this vicious circle and find themselves unable to get out of it.

Two tentative solutions to the apparent problem of lack of liquidity - and its consequent hazards of chronic indebtedness and ultimate loss of control over productive assets - suggest themselves. The first is a re-vitalising of formal credit procedures through banks, cooperatives and so on. This would require a debt amnesty and measures to ensure both the timely availability of funds and high repayment performance. Unfortunately, such measures have been attempted previously in Sri

Lanka but in a piecemeal and inconsistent fashion and have not generated lasting success. Indeed, inadequate measures to secure repayment and repeated granting of debt amnesties are likely to be counterproductive in their effects on willingness to repay. Whilst seasonal credit may continue to be necessary for a considerable period, a second solution may offer better prospects of success in the long-term, namely the effort to make farmers more reliant on generation of their own funds for investment. We have already noted the haphazard and apparently random spending pattern of farmers after harvest. We have also noted (3.4 above) the absence of forward planning necessary to arrange input supply for subsequent seasons' cultivation. A possible measure to a both of these problems could be the psychological and practical preparation of farmers for the subsequent season's cultivation <u>before</u> the existing crop has been harvested. It is well known that a long spell of comparative inactivity precedes the harvest, and yet farmers are generally present at the cultivation sites. An attempt to take the longer view of farming as a continuous activity, not as a series of discrete seasonal efforts, might encourage wiser savings patterns, and reduce the need for seasonal credit and permit adequate preparation of the necessary infrastructural services for the subsequent seasons cultivation. The burdens that might be placed on organisational aptitudes and institutional facilities by attempts to introduce a longer-term perspective of this type, and their prospects of success, will be analysed in a subsequent report.

In addition to issues we have indicated above, such other sociological issues as the leadership pattern, the community organization, the social linkage of power owners and farmers, employment patterns, the communication facilities will be investigated with the data collected through the sociological questionnaire and the unstructured interviews.

APPENDIX I

1.1 SUMMARY OF STUDY OBJECTIVES

The consumption of stored water in paddy production in Sri Lanka is known to be high; in land preparation alone, where irrigation water is allowed to flow freely to assist in mudland tillage, some 2 or 3 acre-feet are commonly consumed. With the increasing exploitation of water resources in gravity irrigation schemes in the Dry Zone, economies in water use are becoming increasingly urgent. This study intends to investigate current use-patterns of farm power and of other farm technologies with a bearing on water consumption, examining particularly the inter-face between power and water in land preparation, in the attempt to suggest new policy directions which are both politically and administratively feasible and yet offer higher net national returns to power and water either individually or, more particularly, in combination.

The study was conceived on the premise that it is critically important to examine the interface between power and water-use technologies with the fundamental objective of exploring current and potential choices in power use and their implications for water-use. From this can be developed advice to policy makers on the appropriate mix of farm power for given sets of circumstances in the Dry Zone, and on policy instruments and institutional arrangements appropriate to the attainment of the recommended combinations.

A further premise of the study is that objective decisions about farm power can only be taken on the basis of detailed analysis at farm level in specific locations. The immediate aims of the study will therefore be to gather sufficient information on resource allocation patterns, input-output ratios, the prerequisities and implications of various technologies, and trade-off relationships among farm inputs to allow systematic modelling of farming and power use systems. The data will be gathered from field surveys of existing practices, by study of research reports on practices not currently used, and by field trails with technology whose potential has not yet been fully explored. Models will then be constructed at farm level in which the most efficient technologies for different farming systems can be identified for various combinations of farm resource availabilities, crops and paddy: upland ratios. Similar models at community level will attempt to investigate power and water management in the broader context. The potential uses of any water saved through alternative land preparation technologies will receive particular attention. Both power demand and supply factors can be studied at this level, the demand being influenced by the various aggregations of individual farm characteristics and requirements, the supply by the number and type of power sources available, by institutional arrangements for owning or hiring them, by the nature and efficiency of institutions managing water, and by the conflicting demands for power in non-farm uses.

In both sets of models, the impact of different power/water technologies on total farm income, returns to land, labour and water, and on the distribution of income between power owners, operators and hirers, and their impact on the use-levels of mechanical, animal and human power will be considered. In addition to analysis at current and projected market prices, shadow pricing exercises will be be conducted to investigate, in particular, the national economic desirability of various power/water alternatives.

Field - level data collection will comprise two sets of surveys:

(a) Farm surveys at 3 locations, Padaviya, Kaudulla and Uda Walawe, will select farmers at the upper and lower reaches of the irrigation system, and collect data on their farming enterprises, both irrigated and rainfed, and the timewise allocation of resources among these. Particular attention will be paid to resource allocation at land preparation, where the power/water interface is strongest, and to choice of technology for land preparation, planting and threshing, these last two operations having potential for a higher degree of mechanisation than is currently used. The attempt will be made to build up a picture of the constraints faced by the farmer, such as capital, power, water and labour availability. The type of sequence of operations in land preparation and amount and method of payment will be closely recorded.

(b) Surveys of the owners of power sources (both tractor and animal) will be conducted to obtain data on the allocation of the power source among operations (farm and off-farm, use by owner or hirer, timewise distribution of uses); to estimate the profitability of operations by obtaining data on costs and revenue; to assess the prospects for repayment of loans, and to obtain an impression of the extent to which restrictive practices and collusion influence hire charges. The attempt will also be made to trace back the accumulation of wealth by the power source owner, particularly in terms of accumulation of land under his ownership or control.

1.2 TIME SCHEDULE OF STUDY ACTIVITIES

The project, designated to run from April 1979 to January 1982, was conceived jointly by the ARTI and Reading University in October - December 1978. Formal approval was granted by ARTI in February 1979, and funds were made available from the budget of the Economic and Social Committee on Research (ESCOR) of ODA in the same month.

The study proposal envisaged the full time employment of 2 economists each of 2½ years, and further two each for 2 years, with a sociologist for 1 year and consultancies in farm power and irrigation each for up to 6 months. A schematic summary of the project timetable is appended.

Field data collection was planned for the two consecutive seasons Maha 1979 - 80 and Yala 1980, and preparatory work started in May 1979. Field work started as envisaged in August 1979. The study team, hitherto comprising J.Farrington and W.A.T.Abeysekera was augmented by the arrival of M.J.Ryan from Reading University in September, 1979. W.A.T.Abeysekera was replaced by F.A. de S.M. Abeyratne in January 1980, and Mrs.S.Bandara was nominated to the study team in the same month, bringing the team to its full complement.

On the sociology side some initial investigations were made by Dr.W.W. Sirisena of Peradeniya University in September/October 1979. Mr.M.U. Ishak Lebbe (ARTI) was nominated to replace him in November 1979, and Dr.Sirisena re-joined the study team as consultant with responsibility for sociological investigations at Padaviya and Kaudulla in February 1980. Mr.M.P.Moore (IDS, Sussex University) was recruited as consultant in Water Management in February, 1980, but a family bereavement required his return to UK a week after his arrival. He returned to resume duties in March 1980.

TABLE I.1 SCHEDULE OF STUDY ACTIVITIES

	Activities	1979												1980												1981											1982
		J	F	M	A	M	J	J	A	S	O	M	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	A	S	O	N	D	J
IIS	Finalisation of study design	■	■	■																																	
IIS	Pre-survey investigations				■	■	■	■																													
IIS	Preparation of field survey staff & schedules					■	■	■																													
IIS	Field study-economics								■	■	■	■	■	■	■	■	o	o	o	o	o	o															
IIS	-sociology									■	■	o	■	■	■	■	o	o	o	o	o	o															
IIS	-water management														o	■																					
IIS	Data tabulation and preliminary analysis													■	■	■	o	o	o	o	o	o															
IIS	Further analysis by computer																						o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
	Staffing																																				
Economics	J.Farrington	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	o				o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
Economics	W.A.T.Abeysekera				■	■	■	■	■	■	■	■	■	■	■	■	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
Economics	F.Abeyratne													■	■	■	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
Economics	M.J.Ryan							o	o	■	■	■	■	■	■	■	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
Economics	S.Bandara							o	o	o	o	o	o	■	■	■	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
Sociology	W.M.Sirisena									■	■				■	■	o	o	o	o	o	o	o	o	o												
Sociology	M.U.Ishak Lebbe												■	■	■	■	o	o	o	o	o	o	o	o	o												
Water Management	M.P.Moor														■	o	o																				
	Vehicles																																				
	Land rover								o	o	o	o	o	o	■	■	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
	Ford								o	o	o	o	o	o	o	■	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o

o = anticipated ■ = actual

APPENDIX II

PRINCIPAL CHARACTERISTICS OF THE STUDY LOCATIONS

UDA WALAWE

Work on the development of the Right Bank (RB) of the Walawe Development Scheme was started in 1963.

The dam and electricity power plants were completed in the latter part of 1967, by which time some £ 30 m. at current prices had already been invested. The earthen dam impounds water from the Walawe Ganga and its tributaries, which drain the central highlands to the South, having a catchment area of some 454 sq. miles.

In 1969, the Ceylon Government requested financial assistance from the Asian Development Bank in development of the R.B. irrigation infrustructure. A comprehensive plan was drawn up, envisaging disbursement of some £26.5 m., with a foreign exchange components of $ 9 m., to be provided as grants and loans by the ADB.

The development plan, scheduled for implementation over 3½ years, sought to bring into full productive use a total of 33,000 acres of land, of which 25,000 were then unirrigated, and 8,000 were being operated below potential. Some 6,500 families would be settled, or be offered improved living conditions.

The plan envisaged the provision of comprehensive credit schemes, and adequate supply of farm inputs and of marketing and storage facilities. Some 500 two-wheel tractors would be supplied by the River Valleys Development Board (RVDB) to re-sell to farmers, or to provide as a hire service. Additionally, two model rice mills would be established by RVDB. An agriculture research and extension centre was to be constructed and operated at Angunukolapelessa at a cost of over $ 5 m. during the project period

The agricultural programme envisaged an irrigated farming system with multi-crop rotation, almost a complete innovation for ceylon agriculture. On the assumption of increased output of 2.1m bushels of paddy by the 5th year of the project and 2.8 m by the ninth year(and 380,000 cwt and 570,000 cwt. respectively of subsidiary crops) the value of production generated at current prices would be Rs.50 m. in the 5th and Rs.70 m. in the 9th year, giving an internal rate of return of 11.1%. It was estimated that sufficient farm-level surplus would be generated to allow purchase of the land by settlers at a price that would permit development costs to be recouped (to the extent of Rs.10,000 per 5 acre farm over 25 years) and permit a water charge of Rs.40 per irrigated acre to be levied.

Whilst the proposed disbursements have been made, performances have fallen well below target. The main inadequacies have been as follows:-

1. Cropping patterns have not been adhered to; specifically, lowland paddy cultivation has been tolerated in the upper tracts (esp. Tracts 2-4)of the scheme on highly porous soils and hilly topography. Consequently, water consumption there has been excessively high (RVDB, Water Management Unit, Embilipitiya, pers. comm.).
2. An additional factor generating higher water use in the upper tracts has been the pre-irrigation settlement of land there, and the consequent design of channel systems to provide water to farms whose layout is not technically optimal for irrigation. For example, some field and distributary channels pass through and not alongside farms, and off-takes have to be provided at both sides of the channel.
3. The water level in an old-established tank (Chandrikawewa), through which the RB main channel pases,has to be maintained at a high level in order to permit adequate through flow to the lower tracts of the scheme. Water losses through excess evaporation and percolation thus occur.
4. The result of excessive water consumption in the upper reaches of the scheme has been the abandoning of plans to irrigate tracts 20, 21 and part of tract 19 at the tail end of the scheme, a total of some 2000 acres.
5. Non-adherence to prescribed cropping patterns has not, however, been confined to the upper tracts. The annual cropped area designated for crops other than paddy, in Chandrikawewa and in tracts 9-19, totalled 31,012 acres, of which only 2,790 were planted to other crops under irrigation, and 2000 acres under rainfed conditions in

the seasons (combined) maha 1978-79 and yala 1979. (Table II.1). Instead, lowland paddy has been widely planted in those tracts where enough water can be obtained, thereby further reducing the water available at the lower parts of branch channels and distributaries. Much of the land which does not have reliable or adequate supplies of water for paddy has simply been abandoned (cf. B.O.P. of tract 19). Only small amounts have been planted to rainfed crops, or to irrigated crops with lower water requirements than paddy (Table II.1).

6. The ADB attempt to introduce irrigated mixed cropping met with little success. Performance in cultivation of the main non-paddy crop, cotton, highlights many of the difficulties that were encountered, and is perhaps worth discussing in some detail (drawing heavily on Farrington, 1979).

Proposals for cotton development at Uda Walawe Project were formalised in an Asian Development Bank appraisal of 1969 (ADB, 1969). Moves to develop cotton there had previously been put forward in the 1966-1970 Agricultural Development Proposals, where it was suggested that some 19000 acres of cotton in rotation with other crops would be grown there under irrigation, following experimental work on the irrigation of these crops at a station to be established in the Walawe basin. In the event, the experimental work, although started at Ridiyagama in 1965 and continued at Suriyawewa, could not be carried out on a full scale until the establishment of the Angunukola-palessa Research Station in 1971, whilst cultivation by Walawe colonists started in Yala 1973.

The ADB proposals envisaged a total of 24,000 acres of cotton on the right and left banks of the Walawe Project, with an average yield of 15 cwts. giving a total production of 360,000 cwts. of seed cotton.

By early 1973, 400 allotments of 2½ acres each had been settled in Tracts 16 and 17 of the right bank (see map). These settlers were required to agree to cultivate cotton in the Yala season and to receive services and inputs provided by the River Valleys Development Board (RVDB), the cost of which would be deducted from the value of their sales.

It was envisaged that the cultivated acreage should be divided up into 250 acres blocks, under the charge of a Cultivation Officer (CO), each C.O. having 5 extensinn workers (KVS) each with a 50 acre block. The entire project would be under the management of the RVDB through a committee consisting of the Resident General Manager, Deputy General Manager (Agricultural Research) and Deputy General Manager (Agricultural Extension). The Assistant General Manager (Cotton) would be in immediate charge.

It is interesting to compare the projected cropping performance at Uda Walawe with what was actually achieved.

The ADB appraisal envisaged a 9 year development of irrigation infrastructure and cultivation at Uda Walawe, to start in 1969 and be completed in 1978, by which time some 9,710 acres would be under cotton. The cotton planting programme did not start until Yala 1973, and its progress is summarised below.

TABLE :II.0 Planned and Actual Cotton Performance at Uda Walawe

	Acreage	Production (cwt. seed Cotton)[2]	Yield (cwt./acre)[2]
Year 1 (1973)			
Proposed by ADB	1,040	10,400	10
Achieved[1]	603	1,881	3.1
Year 2 (1974)			
Proposed by ADB	4,400	44,000	10
Achieved	480	2,596	5.4
Year 3 (1975)			
Proposed by ADB	9.710	126,230	13
Achieved	654	4,731	7.2
Year 4 (1976)			
Proposed by ADB	9.710	145,650	15
Achieved	671	1,815	2.7
Year 5 (1977)			
Proposed by ADB	9.710	145,650	15
Achieved	820	3,036	3.7

Notes: 1 - Refers to acrrage harvested . Data supplied by RVDB.

2 - The yield figures are obtained from records of seed cotton sales through the Project. Farmer's attempts to avoid credit repayment through selling part of their production off the scheme may mean that these figures represent only about 2/3 of true yield and productinn levels, particularly in the later years.

Many of the reasons for this poor performance were identified in internal RVDB reports as early as 1974. They included:

i) the fact that about 1/3 of the settlers in the early years did not take up residence on the project, but supervised their crops in a haphazard fashion from outside the scheme, where their main interests lay.

ii) the late arrival of some pesticide (i.e. Azodrine) in 1973, which allowed heavy build up of American and pink bollworm.

iii) the lack of experience of both settlers and staff in pest control and in irrigation of crops other than paddy.

iv) the poor quality of seed; supplied in 1973 from Ambalantota experiment station, it has been stored since Maha 1971/1972 and two trial batches produced germination of 45% and 18% respectively.

v) poor initial levelling prevented adequate pre-wetting for land preparation; tilling therefore had to be done on hard soil in some places. Similarly, poor levelling prevented the construction of furrows of the planned 200-300 ft. length. The maximum attainable in many parts was only 75 ft.

vi) a host of water management problems, including illicit tapping of water in the upper reaches of the system, leading to insufficient water supplies at the lower end where cotton was grown; malfunctioning of D-channels arising from faulty bed levelling; a supply of irrigation water at a delay of 3-4 days from the time of its requisition; inadequate frequency of issue of irrigation water (only 2-3 issues having been made in 1973); frequent disputes between paddy and cotton cultivators.

vii) inadequate enforcement of cropping regulations, resulting in the widespread cultivation of paddy on highly permeable soils.

viii) problems of labour shortage in mid-season, especially for weeding.

UDA WALAWE

Table II.1

Acreages planned for irrigation of paddy and subsidiary crops, and acres actually irrigated in a typical maha season, by tract.[1]

Tract	Paddy acres envisaged in Blocking Out Plan	Paddy acres actually irrigated maha 1978-9	Subsidiary crops envisaged in BOP[3]	Subsidiary acreages actually irrigated maha 1978-9
2	381	365	0	0
3	687	682	0	0
4	1051	750	0	0
5	565	544	0	0
6	820	808	0	0
7	386	380	0	0
1-5	1668	1800	1044	160
6	1198	433[2]	608	555
Extn. 1	1375	1408	784	202
Extn. 2	907	952	839	222
9	327	1080	1383)	
10	175	368	422)	983
11	50	918	1522)	
12	1589	2649	1373	208
13	493	667	182	0
14	1082	1291	1925	0
15	591	769	370)	
16	497	168	675)	
17	690	1040	750)	200[4]
18	185	393	1082)	
19	25	88	500)	

Notes:- 1. Data provided by RVDB, Embilipitiya, and by RVDB Project Managers, tracts 2-7, Chandrikawewa, Morawasihena, Binkema and Angunukolapelessa. Actual paddy acreages include encroachments.

2. One channel closed for repair.

3. The entry of zero for tracts 2-7 in this column is not atrictly accurate, in that the bulk of asweddumized land here was initially scheduled for sugarcane, but no serious effort was made to encourage its cultivation , and colonists were permitted to continue paddy cultivation even on highly permeable soils.

4. This figure is necessarily approximate in view of the erratic supplies at the tail end of the scheme.

KAUDULLA

Kaudulla has been identified as Tissa Vaddhamanahavapi (Rantisava), one of the 16 reservoirs constructed by King Maha Sena (276-303 A.C). It was later restored by Vijeyabahu (1055-1110) and improved upon by Parakrama Bahu (1153-1186).

Present rehabilitation work started in 1958. The tank receives water through its own catchment (Gal Oya and Alut Oya which now cross the Minneriya - Kantalai Yoda Ela, and thus spill into Kaudulla Tank)and through the natural channel of the Agglawan Oya, which is fed through a gated outlet from the Minneriya tank. Water from the diverson of the Mahaweli Ganga became available to Minneriya for the first time in 1976, and thus also to Kaudulla.

With rehabilitation in 1958, work was started on the construction of stage I. By 1963, 4752 acres of asweddumised land under stage I had been laid out and were irrigated from a low level (210 ft. asl.)sluice. Stage II, of 5935 acres, received its first issues of water in December 1976 from a high level (215 ft.asl)lies to the north-east, between stage II and Kantalai tank, which will form stage III at some unspecified date. Potential for stage IV of 21000 acres has also been identified to the north of the present stage II.

Plot sizes are 3 acres of paddy and 1 acre of highland in stage I tracts 1-6, and 2 acres of paddy and 1 acre of highland in stage I tracts 7-8 and in all of stage II.

Water supply problems at Kaudulla, since the inflow of Mahaweli water, have been rare. However, as Murray-Rust and Cramer (1979) have reported, severe local problems were experienced in Yala 1979; a decision was taken in March 1979 to cultivate the full Yala acreage, on the strength of a promised 27,500 acre-feet of water via the Mahaweli connection, to be split equally among June, July and August. However, by the end of June, the Kaudulla tank level had fallen so low that the high level sluice could not produce adequate head of water to serve the entire acreage, with the result that substantial portions of stage II received no water for periods of 2-3 weeks. This crisis was a combination of external forces (late arrival of the monsoon rains in the Mahaweli catchment; the need to bring the Minneriya tank level to 56000 acre feet before deliveries to Kaudulla could be made;and the preference in water allocation accorded to Kalawewa) and of internal forces, more amenable to improved management. For instance, Murray-Rust and Cramer estimate that in the first 60 days of the yala season at Minneriya (i.e. including land preparation) some 3.3 acre-feet/acre were issued, and at Kaudulla during May alone (i.e exclusively for land preparation) some 2 acre-feet/acre. Had more economy been exercised in these issues, much of the deficit later in the season could have been met.

KAUDULLA

Table II.2

Acreages planned for irrigation and actually irrigated in maha 1978 - 1979 and yala 1979.

Stage I Tract No.	BOP[1] Acreage	Acreage actually irrigated[2] Maha 1978-79	Yala 1979
1	1512		
1b	363		
2	186		
3	264		
4	225		
5	318		
6	326		
7	800		
8	615		
Stage 1 sub total	4609	5250	5169

Stage II

Tract No.	Acreage	Maha 1978-79	Yala 1979
1	246		
2	490		
3	300		
4	914		
5	202		
6	734		
7	370		
8	400		
9	720		
10	468		
11	407		
12	684		
Stage II sub total	5935	5911	5858
Stage I + II total	10,544	11,161	11,027

Notes: 1. Provided by Irrigation Department. Figures exclude about 140 acres in Stage I of school paddy and experimental plots.

2. Data provided by Agriculture Instructors, Medirigiriya.

PADAVIYA

Padaviya is located some 50 miles north-east of Anuradhapura. The tank bund, of some 2½ miles in length, runs east-west and the irrigated tracts curve round to the east, coming within a mile of Kokkilai Lagoon on the east coast.

The construction of the first tank at Padaviya is of uncertain date. However, it is known to have been preceded by an anicut (Vannathipalam) about 1 mile below the confluence of the Kiul Oya and the Ma Oya. This anicut permitted land to be irrigated on both banks of the river, down almost as far as Kikkilai Lagoon.

These ancient works are unlikely to have provided more than adequate water for a single (Maha) crop, and the desire for irrigation water also in yala may have been a prime factor in construction of the tank. The first tank, identified as Ratmalkandha Vapi of Mahasena and Danavapi of Moggollana (535-555 AD), later known as Padivapi, was constructed some 6 miles south (i.e. upstream) of the ancient anicut. It is known to have fallen into disrepair prior to 1140 AD, and was restored by

Parakramabahu I (1153-1186). It fell into disrepair for a second time in the second half of the thirteenth century, at about the time of the decline of the Polonnaruwa civilisation.

Only in the early 1950s was the jungle which covered Padaviya rolled back. Rehabilitation was started in 1954 and completed in 1958, the tank bund, impounding the waters of the Makunu and Mora Oyas being reconstructed on its previous site.

The present tank, with a storage capacity of 72,500 acre - feet from a catchment of 106 sq. miles, irrigates some 12500 acres in Maha, and in most years, about one third of this acreage in Yala. The tank is rarely filled to capacity, and in the Yala season, settlers from the lower part of the command area are brought to share the plots of those settled at the upper end, under the "bethma" system.

A paddy-paddy rotation in irrigated tracts is predominant, with highlands mainly planted to tree crops. Some cultivation of non-paddy annual crops in the uplands is practised, chiefly as rainfed crops, but occasionally (illicitly) using water pumped from irrigation channels. Encroachment of lowland paddy onto channel, road and river reservations is widespread in the upper part of the command area. Water supply is problematic particularly in the lower reaches of tract 6 (D15) and in tracts 12 and 13 at the tail end of the scheme.

Allotted holding sizes are 3 acres of paddy and 1 acre of highland with the exception of tracts 12A and 13, where the paddy lot is only 2 acres.

Table II.3

Acreages planned for irrigation and actually irrigated in a typical Maha season, by tract.[1]

Tract No.	Paddy acreage envisaged in Blocking Out Plan	Acreage un-irrigable or abandoned	Acreage encroached	Actual acreage irrigated in a typical Maha
Lower main channel				
1	123	9	40	154
2	453	5	120	523
3	261	60	30	231
4	108	12	15	111
5	624	50	30	604
6	2097	90	200	2207
7	567	45	35	557
8	423	20	35	438
9	1071	150	250	1171
10	710	40	90	760
11	455	50	20	425
12	908	353	0	555
12A	146	40	0	106
13	700	412	0	288
sub total	8646	1381	865	8130
Upper main channel				
A	495	15	70	550
B	403	50	50	403
C	654	60	60	654
D	522	40	85	567
E	1936	120	200	2016
sub total	4010	285	465	4190
total	12656	1666	1330	12320

Notes:-1. BOP data were supplied by the Irrigation Engineer, Padaviya. Areas unirrigable or abandoned were obtained from field records maintained by the Irrigation Department staff. Some inaccuracies may result from rounding of individual observations, and particularly by the encroachment by neighbouring farmers onto any parts of the allotments which remain irrigable in spite of officially being recognised as unirrigable.

2. Reliable data on encroachments are not available; the data presented were obtained from discussions with Irrigation Department field staff and from their indications of areas encroached on the Blocking out Plan. They and the resultant "actual acreages irrigated" in column 4, should therefore be treated with caution.

APPENDIX III

III.1 INTERACTIONS BETWEEN THIS STUDY AND RESEARCH AT ARTI AND ELSEWHERE

The study proposal contains a comprehensive list of on-going research and data collection of relevance to study objectives. It is not proposed to re-iterate that account here; instead, attention is focussed on a small number of projects of strong interest to the study, and the scope for interaction is explored in some depth. Attention is drawn particularly to two important studies of labour in the dry zone (III.1.1-2) which were initiated because of the importance of their individual themes, but were also conceived as complementary to the present study in so far as they broaden the framework of analysis of farm power. To some degree, therefore they have arisen out of the initial concept of the Farm Power study. More recently, an interest has developed within the research team in the broader issues of energy supply and consumption in the rural sector. A background paper, focussing on energy costs of farm power, is already in press, and is summarised below.(III.2).

III.1.1 ARTI STUDY ON SEASONALLY MIGRANT LABOUR

(G.A.Crooks and H.A.Ranbanda)

This study, now in the final draft, examines the setting in which seasonal migration of labour between wet and dry zones has arisen. It identifies the marked seasonality of peak labour requirements in paddy production in the dry zone, which coincide with slack periods in the wet zone, as a prime factor in such movements. The limited scope for labour-saving innovations in these operations, the small resident pool of potential hired labour in the dry zone itself, the ties between settlers and their villages of origin in the wet zone and the better social and economic infrstructure in the wet zone, which encourages people to remain resident there, even if they can only earn a living through piecemeal and casual employment, all reinforce the tendency for seasonal migration. The study shows that wages and incomes are considerably higher in the dry than in the wet zone rural sector, and that earnings from migration make up a high proportion of total family income for migrants. It is suggested, therefore, that the system as observed is of strong individual economic benefit to both migrants and to dry zone farmers; is beneficial at a national economic level through shifts in productive resources from areas of low to areas of high marginal and average productivity and through transfers of at least part of the wealth earned in the dry zone to the relatively impoverished areas of the wet zone.

Projections of labour requirements for Mahaweli development, drawing on Fieldson and Farrington (1980), are made, and the conclusion is reached that the volume of migratory labour will have to be expanded strongly to meet these labour requirements for the future.

This work is of strong relevance to the study insofar as it analyses the timing and volume of labour and income flows between wet and dry zones. Analysis of potential strategies for more efficient use of water and farm power must take into account any impact on the labour market, and this study provides insights into important aspects of that market. This work, taken together with the study of family labour supply response (see III.2) will provide a powerful set of data on and interpretations of rural labour availability in the dry zone.

III.1.2 ARTI STUDY ON FARM LABOUR SUPPLY RESPONSE IN DRY ZONE IRRIGATION SCHEMES WITH IMPLICATIONS FOR PLANNING IN THE MAHAWELI GANGA DEVELOPMENT PROJECT. (R.S.Fieldson)

An understanding of the labour market is critically important to the Farm Power study: going beyond simple labour-displacement hypotheses, it is necessary to know what types of labour (particularly whether family or hired labour) might be displaced, and at what times during the season, by increased mechanisation. Similarly, the aspirations and motivations of family labour with increasing net returns per farm are of strong interest: is family labour likely to devote more or less time to farming with increasing incomes. Again, does conventional wisdom regarding higher per acre labour inputs on smaller farms hold true for Sri Lanka's dry zone, a question with strong implications for the selection of appropriate allotment sizes for future settlement, and for the relative efficiencies of different types of farm power, which will vary with farm size.

This work by Fieldson draws together data from a number of different studies of dry zone agriculture which have been undertaken (at ARTI and elsewhere) over the last decade or so in an attempt to examine and explain variations in observed labour inputs. Much of the early work was involved with the selection of suitable data, and various problems of comparability had to be overcome. But a total of 15 sets of data for 12 different locations were finally deemed acceptable, all referring to the Maha season and all relating to paddy production.

A large amount of variability between labour inputs at different locations was observed, and a number of variables are being examined which might account for this. For instance, the attempt has been made to examine the relationships between labour input and: the average area of paddy cultivated per farm; the degree of tractorisation, and the net returns to paddy production. Separate figures are available for hired labour input and family labour input (and, in some cases, exchange labour input) so the relationships can be examined separately for these different categories.

Future work will include some examination of the effects of family size on labour supply, attempts to isolate the way in which the reliability of water supply influences labour input, and an effort to adopt a "whole farm " approach to labour supply - looking at enterprises other than irrigated paddy production.

A further interesting area of study which will probably be explored more fully is the extrapolation of the findings from a "per acre" or "per farm" level to a much wider level, eg., the whole of the planned Mahaweli Development Area. This allows the implications of the findings for the country's development to be made much clearer.

Some of the preliminary results of the study have been published in a seminar paper by Fieldson and Farrington (1980) and can be outlined briefly here:

(a) No evidence was found of systematic relationships between total labour input per acre and the area of paddy cultivated. There was weak evidence of lower family labour inputs with larger operated holding sizes, and strong evidence of higher hired labour inputs with larger operated holding sizes.

(b) Although, as predicted in other studies, smaller total labour input per acre was found to be associated with higher levels of tractorisation, there was no evidence of systematic relationships between the level of mechanisation and the input of hired labour. The input of family labour, on the other hand, was found to be consistently smaller at higher levels of mechanisation, suggesting, contrary to conventional thinking, that it might be family and not hired labour which is "displaced" by mechanisation. This finding is preliminary and will be tested against such other variable factors as the availability of irrigation water.

(c) There seems to be a strong relationship between the aggregate input of labour into paddy per farm and the net returns from paddy per farm, and between the input of hired labour per farm and the net return from paddy. The direction of causality is, however, not clear at present, and will be the subject of further investigation in 1980. No clear relationship was found between the input of family labour and the net returns from paddy. Whilst this may be attributable to data inadequacies, the authors feel that a more likely explanation lies in the preoccupation of the farm family in non-farming activities, or in leisure. Again, this finding will be the subject of further investigation.

(d) Making projections for the whole of the Mahaweli Project, the above results imply that a much higher input of hired labour will be necessary (if output targets are to be met) than seems to be anticipated at present. As even now, labour is in short supply at peak periods in the dry zone, a large increase in the number of workers migrating seasonally from the wet to the dry zone seems inevitable (somewhere between ½ and 3/4 of a million workers is tentatively suggested).

The study will be completed by October 1980.

III.1.3 SRI LANKA - IDRC RESEARCH INTO CROPPING SYSTEMS

This work, based at Maha Illuppallama Research Station, started in 1977 and will continue at least until 1981, and is financed by a grant from the IDRC to the (then) Ministry of Agriculture and Lands through the International Rice Research Institute. Its primary purpose is to investigate the scope for bringing forward the cultivation calendar in minor tank (less than 200 acres command area) paddy production, thus permitting more intensive land use through planting of a second paddy crop irrigated by surplus tank water. The main technological changes envisaged as necessary to achieve such intensification are tractorised land preparation at or before onset of the rains, (i.e., without the traditional use of water for puddling), planting with the first rains of the monsoon (Maha) and use of supplementary irrigation through the season only in so far as necessary for crop growth (i.e., not as a weed control technique). These practices should permit the bulk of stored tank water to be saved for a second paddy crop.

Field work has concentrated on three villages: Walagambahuwa (Anurahdapura), Kataputa (Kurunegala) and Karandankulama (Anuradhapura). The first grows lowland rice, whereas the other two produce chiefly upland (rainfed) rice. The programme is furthest advanced at Walagambahuwa, where in 1977-8 (Maha) tractorised land preparation was provided free of charge, and the full extent of irrigable land was sown to two consecutive crops of paddy, this being the first time that even a Maha crop had been taken in 6 years. It is clear that this work has considerable relevance to the ARTI/Reading Project. It raises questions, for instance, of whether mechanised power is a pre-requisite for bringing forward and synchronising the cultivation calendar at minor tanks; it also raises broader questions of the profitability of tractor-use when ownership is located within small communities, and of the extent to which the novel cropping systems introduced at Walagambahuwa, with a high degree of agreement among farmer on water use, is sustainable without the heavy inputs of supervision provided there by research staff.

III.1.4 SRI LANKA - USAID RICE RESEARCH

The proposal for this study was submitted to USAID on 22.6.76 IAID/DLC/P-2189). It represents an expansion and strengthening of the work described above under the Sri Lanka-IDRC Cropping Systems Research. It initially envisaged a 5 year programme of long-term technical assistance (total 15 man-years) funded by a $ 4.2 m loan with a counterpart contribution of Rs. 47 m. Its primary objective is to "expand the technological base underpinning the current use of Sri Lanka's paddy land through the development of improved rice varieties and improved cropping systems to allow for greater paddy land use intensities". (p.11).

On the research side, it envisages support to a decentralised network of rice research stations (at Bombuwela, Bandarawela, Gannoruwa, Maha Illuppallama and Angunukolapelessa) each corresponding with a broad agro-ecological zone, and each associated with the Central Rice Breeding Station (Batalagoda). These stations will be strenghened in order to assist in breeding programmes designed to incorporate resistance to pests, diseases, drought, flood, cold and problem soil conditions, each according to agro-ecological zone. A Field Trials Division unit will be established at each station to coordinate and assist in designing field experimentation.

Cropping systems work is designed to introduce early tillage and supplementary irrigation (as described for the Sri Lanka - IDRC Programme, above) into rice growing lands in order to raise from some 75% to 100% the probability of growing a single rice crop on some 350,000 acres of partially irrigated (i.e. minor tank) land. Sufficient water in many areas should be left over for cultivation of a second rice, pulse or grain crop. The programme, by use of similar techniques, intends to increase cropping intensity on the 260,000 acres of rainfed rice in the dry zone and 75,000 acres in the wet zone, and on the 150,000 acres of partially irrigated land in the wet zone.

Data will be collected at survey sites on weather, topography, irrigation, soil type, marketing systems, land tenure, input use and farm resources available as baseline data prior to the introduction of improved cropping systems. Each field site will have one Research Officer (Agronomy), two Experimental Officers or Agricultural Instructors (at least one economist) and supporting staff.

To data, field sites have been established at Kattiyawa (within Mahaweli "H" Area); Paranthan (a rainfed paddy area on light soils, near Elephant

Pass, Jaffna); Mannar (a site within the Giant's Tank complex, heavy deltaic soils); Bandarawela (low degree of mechanisation, hilly topography, located in mid-country Intermediate Zone); Angunukolapelessa (Southern Region dry zone, much land irrigated by small tanks, high degree of mechanisation).

The project also proposes to conduct a resource capability survey to assess the resource capability and productivity potentials of Dry, Intermediate and Wet Zone paddy areas, to facilitate extension of the cropping systems findings. The survey will identify and classify valley and terraced slope irrigation systems, delineate slope categories in these systems and conduct a soil survey, characterisation and mapping exercise at medium-intensity level.

It is clear that this work has considerable relevance to the proposed field-level research of the ARTI/Reading Study. The network of field sites embrace widely varying conditions of climate, soils, topography, water availability, power use and farming systems. Much detailed data will be generated by this work, and it is proposed that the ARTI/Reading Study should take advantage of the available information, supplementing it, where necessary, by surveys on farm power market conditions, profitability of tractor-use, institutional ownership/hiring arrangements, the role of middlemen in power supply, water management systems, etc.

III.1.5 A SRI LANKA - CANADA - COLOMBO PLAN PROJECT FOR RESEARCH AND DEVELOPMENT OF RAINFED AGRICULTURE IN THE DRY ZONE OF SRI LANKA

(Short Title : Sri Lanka - Canada Dry Zone Project).

This project is described in a report submitted to CIDA in 1976 following a visit to Sri Lanka in February-March by specialists in weed science, dairying and operational research. It examined research and development requiring support as a pre-requisite for agricultural development in the Dry Zone, and proposed a 5-year project to identify and strengthen weak components in the "existing research-based agro-technical farming systems". For instance, at Maha Illuppalama it proposed the strengthening of research and training in weed science, agricultural engineering and forage crops utilization.

The report also proposed assistance in the establishment of pilot development schemes.

The cost to Canada will be $1,230,000 (for expertise, transport, housing, laboratory and farm equipment) and the Sri Lanka input will be Rs.5,800,000. It is proposed to develop a close liaison with the All India Coordinated Research Project in Dryland Agriculture. The project began in 1978.

The first pilot development scheme is to cover an area of some 5,000 acres, containing 4 or 5 minor tanks (i.e. with less than 200 acres command area), with some 500 families. The project intends to study farming systems embracing both irrigated/rainfed and crop/animal production options in minor tank villages. It is proposed that "Research and extension personnel would try to saturate a given area with all available known technology while allowing the farmer's constraints to operate, and thus evaluate the socio-economic benefits of improved dry zone agricultural technology on a large scale". The aim is to give "basic information needed to formulate large scale settlement schemes". Unfortunately, it is not clear what the nature of this information will be nor what lessons will emerge for the longer-term development of the dry zone from attempts to saturate a small area with improved technology at extension service densities which cannot be sustained over wider areas. Nonetheless, it is already clear that this study will produce data on the performance of a range of animal-drawn implements, particularly appropriate to non-paddy cultivation, which have not so far been used in Sri Lanka. These data will be of strong relevance to the study.

III.1.6 TANK IRRIGATION MODERNISATION PROJECT

A. Summary of Project Objectives and Methods:

The rehabilitation of structures in 5 major irrigation schemes in Anuradhapura District (Padaviya, Mahakandarawa, Mahawilachchiya), in Vavuniya District (Pavatkulam) and in Mullaitivu/Mannar Districts (Vavunikulam) is being executed by the Sri Lanka Irrigation Department and funded largely by the World Bank and U.K. Overseas Development Administration.

Apart from the provision of improved irrigation structures, the modernisation programme envisages an improved system of water management and a strengthened agricultural extension service.

The proposed improvements relate to both agriculture and water management. They are described below, drawing heavily on Parker (1978b).

1/ Agricultural Programme:

The following broad objectives are specified:

i) Increasing the number of crops per year
ii) Raising the profitability of each crop
iii) Promoting a balanced, stable and viable system of agriculture.

Major constraints to achievement of the above, and means of overcoming them, can be identified as:

i) Poor timing of the seasons, preventing full use of rainfall in crop production.
  - to be overcome by:
  (a) Provision of greater quantities of farm power; provision of support services for the same, and manipulation of power use.
  (b) Weaning farmers away from mudland tillage techniques which rely on flooding by tank water, by introduction of more farm power and improved implements to permit dry or semi-wet land preparation in the low rainfall months of August and September.
  (c) Weaning farmers away from a full tank mentality, which has caused them to delay the start of land preparation until rainfall has been adequate to fill the tank. Achievement of this objective depends on building up farmer confidence in the scheme management and the establishment of suitable insurance for a paddy crop which is partly rainfed.
  (d) Provision of adequate and timely credit to permit the early hiring of farm power.
  (e) A higher degree of synchronisation of land preparation and planting and the speeding up of operations such as tilling and threshing by the provision of more farm power.

ii) Wastage of water

- to be overcome by:

    (a) The construction of water control and measurement structures.
    (b) Increased disciplinary action against illicit use of water; the encouragement of cooperative water use among farmers; the promotion of moist instead of mudland cultivation; the promotion of weed control strategies which do not rely on retention of standing water.

iii) Low profitability of each crop

- to be overcome by:
    (a) Improving irrigation and drainage facilities.
    (b) Making farm inputs more readily available.
    (c) Improving farmers' technical knowledge and the implements at their command.
    (d) Encouraging a more responsible use of seasonal and medium term credit.

iv) Low level of general management

- to be overcome by:
    (a) Introduction of electoral principles to farmers' organisations, and better representation of farmers on the Tank Committee.
    (b) Increased discipline in government departments with which the farmers have to deal, and reduced overlapping of duties.
    (c) Establishment of a monitoring system to provide a flow of information on farming back to project staff.

v) Instability of the agricultural system

- to be overcome by:
    (a) Promotion of 2 irrigated crops per year and of other crops to yield incomes at times of cash scarcity.
    (b) Reducing farmers' dependence on outside supplies and services by encouraging them to build up their own stock of power,

implements etc.

(c) Diversification of enterprises to encourage livestock/crop integration and to employ any currently underutilised resources.

2/ Water Management Programme

The new irrigation design to be introduced with rehabilitation relies on the concept of a 'turnout' area, i.e. a block of some 40 acres of irrigable land with an outlet from the main or distributary channel. This outlet will have a standard capacity of 1 cusec; it will be lockable and will be fitted with a measuring device.

Within the turnout, each 3-acre farm will be fitted with an outlet capable of delivering 0.5 cusec, so that two farms can be irrigated simultaneously. It will take 3 days to deliver a standard issue of 2" of water to a turnout of 36 acres, thus permitting a rotation between two turnouts within one week. The on-farm delivery envisages a 12-hour rotation which would be necessary to issue 2" of water to a 3 acre farm. Two 12-hour issues would be made per day, thus requiring the overnight presence of some farmers.

The new system relies on more rapid delivery of water to farms, with a 6" diameter farm outlet, as against the 3" or 4" dia. outlet of the former system. Whilst this may permit the saving of water and its more equitable distribution through the more rapid rotation, it is also more open to abuse within turnouts, the volume of water which could be misappropriated with a 6" outlet being obviously greater than with a 3" or 4" outlet within a given time. Thus the greater is the need for cooperation among farmers within turnouts.

It is envisaged that the new system, whilst adequate to meet the evapotranspiration requirements of the crop, will not be able to convey adequate water for mudland tillage or for weed control by standing water.

The programme envisaged steps to generate cooperation among farmers within turnouts and delegation of some water management responsibilities from staff to farmers in anticipation of the introduction of the new system. It also proposed that research should be undertaken into new land proporation and weed control techniques requiring minimal quantities of stored water.

B. Anticipated Benefits of Interaction

Informal collaboration with this Project has already led to cross-fertilization of ideas on a number of issues, particularly those relating to farm power ownership and use. It is clear that the objectives of the Project have much in common with the spatially more ambitious objectives of the present study. In particular, it is anticipated that future collaboration will yield results of mutual benefit in the following areas:

1) The study of new in-field systems of water delivery to farmers, including the "split channel" design of the TIMP described above, and concrete pipe and stop cock methods under experimentation by Merriam (1979). Whether such systems, by more precision and equity in timing and quantities issued, will lead to higher returns to water, with or without potential impact on use-patterns of farm power, is clearly an issue of major importance to the present study.

2) The programme of experiments with implements for 4-wheel tractors has been described by Russell (1980), following a critique of the technical inadequacy of 4-wheel tractor and implement performance (Russell, 1978). Although this work focusses heavily on only one of the power sources with which the present study is concerned, it represents, nonetheless, a potentially valuable source of information on the work-rates, tillage properties and costs of power/implement combinations not observed in commercial use in Sri Lanka.

3) Management structures for the TIMP tanks have been proposed (Parker, 1978a; 1979) with the objective of removing many of the institutional rigidities, particularly between those responsible for irrigation and those responsible for agriculture, visible in many major irrigation schemes. Other objectives include a more timely, consistent and rigorous approach to the issue of irrigation water and of other crop inputs, involving reporting systems on crop acreages, yields, water shortages and so on.

Since the present study aims to develop practical methods for improving the combined use of power (and other inputs) and water, and is acutely aware of current administrative shortcomings, particularly in water management (see Annexe), the TIMP efforts to improve and coordinate scheme management deserve much attention. Proposals for the present study to monitor their progress have already been drawn up (attributable to M.P.Moore), and are annexed to this Appendix.

4) The TIMP objective of encouraging farmers to purchase their own farm power source and the proposed credit guidelines for tractor purchase (Parker 1988c) are of much interest to the present study. Our research methodology is designed to detect use-differences between owners who are predominantly small businessmen and those who are farmers If significant differences are detected which suggest, say, that the better policy is one of placing power in hands of farmers, then experience with the TIMP proposals will be of much interest.

III.1.6 ANNEXE:

PROPOSALS FOR STUDYING THE EFFECTIVENESS OF TANK COMMITTEES ON THE TANK IRRIGATION MODERNIZATION (5-TANKS) PROJECT

Our interest in these committees arises from the observed need to replace the existing system of seasonal Water Meetings with some more permanent representative institution able to both prepare cropping/water use decisions at an earlier and more useful time and undertake a continous decision making and monitoring programme in order to permit flexibility in the face of variable local factors, especially water availability.

On the Five Tanks Project the Tank Committees were originally intended to be part of a wider institutional re-organization, including the appointment of Scheme Managers with wide authority over each project (Parker, 1978a; 1979). This has not proved possible. Further, the Tank Committees appear to have been allotted important roles in relation to the Moderni zation Project. It follows that the functions and working of Tank Committees on other schemes may be somewhat different.

An important aspect of the study will be to distinguish the functions of the committees as conceived by (a) the original proposers; (b) officials at present working in the schemes; (c) committee members; (d) farmers. One might begin with the following categorisation of functions:

1) Those related to planning and executing the physical investments in irrigation system rehabilitation under the Tank Irrigation Modernization Project.
2) Those related to planning seasonal irrigation programmes, i.e. the job normally performed (imperfectly) by the Water Meetings.
3) Those related to the day-to-day management of water, i.e. the opening and closing of gates, emergency repair of breaches, etc.
4) Those related to the regular maintenance programme of the Irrigation Department, e.g. particularly local problems of persistent inadequacy of water, broken structures, channel clearance, etc.
5) The programme of monitoring local water needs/availability which was part of the original conception of the Five Tanks project, and to be pursued with the assistance of Tank Committee members.
6) Other functions, to be detailed, e.g. assisting in the allocation of tractors as part of the Five Tanks Project.

The main method will be interviews with as many of the following as possible - (a) officials currently working there; (b) officials formerly working there; (c) current and former expatriate advisers; (d) junior staff currently on the schemes, especially Irrigation Department Works Supervisors, maintenance labourers and sluice-keepers; (e) current committee members, and ex-members if there are any; (f) farmers randomly encountered in fields near roads; (g) farmers encountered at the tail ends of D-channels and in tail-end tracts. The minutes of each committee will also be examined.

It would be best to cover all schemes, but the availability of resources will determine whether this is possible. If resources are inadequate, a detailed study of two schemes (including Padaviya) should provide a good basis for a more rapid appraisal of the other three, but not such a rapid appraisal that possible contrasts on new issues cannot be investigated.

It is not possible to specify here all the possible questions of interest. In addition to those mentioned above, the following will be pursued:

1/ What is the procedure for convening meetings ?

2/ Who has the power to convene?

3/ What happens in meetings?

4/ Are decisions adhered to?

5/ What are the occupations and backgrounds of committee members?

6/ Why do they undertake these jobs?

7/ What mechanisms are there for interchange of information between farmers and members?

8/ Have committee posts fallen vacant? Have they been re-filled?

9/ How faithfully do members attend meetings?

10/ Do members see senior Irrigation Dept. staff outside meetings?

III.1.7 ZERO TILLAGE

This work, under Dr.Ray Wijewardena, was initially conducted at the International Institute of Tropical Agriculture, Ibadan, Nigeria, at both experimental and large-scale field-trial levels. It showed considerable promise, and has now been taken up in experimental and field trial work in Sri Lanka, based at the Maha Illuppallama Dry Zone Research Station, by Dr.Wijewardena himself.

The technique relies on two spray applications of herbicide (pre-planting and pre-emergence) by battery-operated spinning-disc ULV machines. No tilling of any kind is done. Row-planting is recommended as a complementory technique, using hand-drawn equipment designed for this purpose.

This is clearly a revolutionary technique of land preparation, offering the farmer adequate weed control at much lower costs for labour and other farm inputs. Current development concentrates on rainfed upland crops. Whether the technique can be implemented by smallholders on a large scale both in upland and in irrigated lowland crops will be closely monitored by the study team.

III.2 OTHER RESEARCH GENERATED BY THIS STUDY

III.2.1 Studies on energy in the small farm sector

The recent seminar organised by the Sri Lanka Association for the Advancement of Science on Energy (January 1980) led to a request from the seminar organisers to the study team to prepare a paper on energy requirements in small farming. Within the short time available, it was possible to summarise the financial and real economic costs of both fuels and other capital and running costs for land preparation by 4 wt., 2 wt. and buffalo, and threshing by 4 wt. and buffalo. The data presented suggested that the financial costs of both operations were higher by tractor than by animal power, and that the discrepancy became wider when real costs to the national economy were considered. The authors suggested that future trends in world market prices of fuel and of tractors would result in an increasing divergence between the costs of performing these operations by tractor and by animal power. Drawing on Farrington and Abeysekera (1979), it was suggested that only in few cases would it be impossible for animal power to perform the operations now widely done by tractors, and that, with adequate supplies, the timeliness of cultivation should not suffer. It was therefore proposed that policy attention might focus on strengthening draught animal breeding programmes, with a corresponding reduced emphasis on tractor imports.

With the recent establishment of a Presidential Committee to design environmental and energy policies (Ceylon Daily News, 24.4.80), this issue clearly assumes urgent importance, and it is one which the study team intends to pursue in the remainder of the study period, amplifying and refining the analysis already undertaken. With the commencement of experimental work in Sri Lanka under the IITA zero tillage programme, additional data on the very low energy requirements of this novel technique will become available, and it is intended to collaborate closely with this study in the energy field.

APPENDIX IV

TABLE IV.1 CHARACTERISTICS OF OWNERS SAMPLE

UDA WALAWE

1/ Uda Walawe - Tracts 2-7 and Embilipitiya Town

	Allottees		Non-Allottees residing on scheme		Non-Allottees residing off scheme		Total	
	Popn.	Sample	Popn.	Sample	Popn.	Sample	Popn.	Sample
1. Owns 4 wt only	4	4	7	7	0	0	11	11
2. Owns 2 wt only	71	5	11	4	0	0	82	9
3. Owns buffalo only	17	12	1	1	0	0	18	13
4. Owns 4 wt & 2 wt	3	2	2	2	0	0	5	4
5. Owns 4 wt & buffalo	0	0	0	0	0	0	0	0
6. Owns 2 wt and buffalo	1	1	0	0	0	0	1	1
7. Owns 4 wt & 2 wt & buffalo	0	0	0	0	0	0	0	0
8. Owns 2 or more 4 wt	0	0	0	0	0	0	0	0
9. Owns 2 or more 2 wt	6	3	1	1	0	0	7	4
Sub Total							124	42

2/ Uda Walawe - Tracts 15-19

	Allottees		Non-Allottees residing on scheme		Non-Allottees residing off scheme		Total	
	Popn.	Sample	Popn.	Sample	Popn.	Sample	Popn.	Sample
1. Owns 4 wt only	0	0(1)	2	2	3	3	5	5(1)
2. Owns buffalo only	22	5	3	3	3	1	28	9
3. Owns buffalo only	24	5	8	1	9	4	41	10
4. Owns 4 wt & 2 wt	0	0	0	0	1	1	1	1
5. Owns 4 wt & buffalo	0	0(1)	0	0	0	0	0	0(1)
6. Owns 2 wt & buffalo	3	2(1)	0	0	0	0	3	2(1)
7. Owns 4 wt & 2 wt & buffalo	0	0	0	0	0	0	0	0
8. Owns 2 or more 4 wt	0	0	0	0	0	0	1	1
9. Owns 2 or more 2 wt	1	0	0	0	0	0	1	0
Sub Total							80	28(3)
Grand Total							204	70(3)

Note: Figures in brackets are those owners Tracts 10 and 11A, for which population data are not presented.

(2) Padaviya Tracts 7-9. E

	Allottees		Non-Allottees residing on scheme		Non-Allottees residing off scheme		Total	
	Popn.	Sample	Popn.	Sample	Popn.	Sample	Popn.	Sample
1. Owns 4 wt only	14	5	2	2	0	0	16	7
2. Owns 2 wt only	36	6	1	1	0	0	37	7
3. Owns buffalo only	287	13	0	0	0	0	287	13
4. Owns 4 wt & 2 wt	1	1	0	0	0	0	1	1
5. Owns 4 wt & buffalo	9	4	0	0	0	0	9	4
6. Owns 2 wt & buffalo	11	6	0	0	0	0	11	6
7. Owns 4 wt & 2 wt & buffalo	0	0	0	0	0	0	0	0
8. Owns 2 or more 4 wt	1	1	0	0	0	0	1	1
9. Owns 2 or more 2 wt	0	0	0	0	0	0	0	0
Sub Total							362	39

(3) Padaviya Tracts 10-12

	Allottees		Non-Allottees residing on scheme		Non-Allottees residing off scheme		Total	
	Popn.	Sample	Popn.	Sample	Popn.	Sample	Popn.	Sample
1. Owns 4 wt only	11	7	0	0	0	0	11	7
2. Owns 2 wt only	7	7	0	0	0	0	7	7
3. Owns 4 wt & 2 wt	26	7	0	0	0	0	26	7
4. Owns 4 wt & 2 wt	0	0	0	0	0	0	0	0
5. Owns 4 wt & buffalo	0	0	0	0	0	0	0	0
6. Owns 2 wt & buffalo	1	0	0	0	0	0	1	0
7. Owns 4 wt & 2 wt & buffalo	0	0	0	0	0	0	0	0
8. Owns 2 or more 4 wt	1	0	0	0	0	0	1	0
9. Owns 2 or more 2 wt	0	0	0	0	0	0	0	0
Sub Total							46	21
Grand Total							452	69

APPENDIX V SCHEDULES USED IN DATA COLLECTION

The schedules relevant to farmers, are presented first, followed by those relevant to the owners sample. Note that schedule 6 is used for both, and that the size of the sociology schedule prevents its inclusion here.

TABLE IV.2 CHARACTERISTICS OF OWNERS SAMPLE - KAUDULLA

	Allottees		Non-Allottees residing on scheme		Non-Allottees residing off scheme		Total	
	Popn.	Sample	Popn.	Sample	Popn.	Sample	Popn.	Sample
1. Owns 4 wt only	7	7(4)	0	0	0	(2)	7	7(6)
2. Owns 2 wt only	21	14	0	0	0	0	21	14
3. Owns buffalo only		25	0	0	0	0	0	25
4. Owns 4 wt & 2 wt	2	1(2)	0	0	0	0	2	1(2)
5. Owns 4 wt & buffalo	4	4(1)	0	0	0	0	4	4(1)
6. Owns 2 wt and buffalo	13	8	0	0	0	0	13	8
7. Owns 4 wt & 2 wt & buffalo	1	0	0	0	0	(1)	1	(1)
8. Owns 2 or more 4 wt	0	0	0	0	0	0	0	0
9. Owns 2 or more 2 wt	0	0	0	0	0	0	0	0
					Total			59(10)

Note: Figures in brackets represent sample selected from Minneriya St.IV, for which population data are not given.

TABLE IV.3. CHARACTERISTICS OF OWNERS SAMPLE - PADAVIYA

(1) Padaviya Tract 2 and Padaviya Town

	Allottees		Non-Allottees residing on scheme		Non-Allottees residing off scheme		Total	
	popn.	Sample	Popn.	Sample	Popn.	Sample	Popn.	Sample
1. Owns 4 wt only	6	0	12	3	0	0	18	3
2. Owns 2 wt only	9	0	3	3	0	0	12	3
3. Owns buffalo only	9	3	0	0	0	0	9	3
4. Owns 4 wt & 2 wt	1	0	0	0	0	0	1	0
5. Owns 4 wt & buffalo	0	0	1	0	0	0	1	0
6. Owns 2 wt & buffalo	0	0	0	0	0	0	0	0
7. Owns 4 wt & 2 wt & buffalo	0	0	0	0	0	0	0	0
8. Owns 2 or more 4 wt "	0	0	3	0	0	0	3	0
9. Owns 2 or more 2 wt	0	0	0	0	0	0	0	0
					Sub Total		44	9

APPENDIX V

A NOTE ON THE SIZE AND DISTRIBUTION OF THE NATIONAL FARM POWER STOCK:

In the body of this report we have discussed the densities and use-levels of farm power at the study locations (3.1,3.2). Here we attempt to provide a broader context for our observations, by compiling data by agro-ecological zone for the country as a whole. The data for this exercise are of dubious reliability. Assumptions have to be relied upon extensively in determining what portion of the farm power stock is in working order, what the work rate is in land preparation, and so on.

Such data and assumptions are, however, the basis of a current policy-oriented farm power planning exercise (FAO, 1980), and we feel that some re-working of the data, with some comments on the FAO methodology, would be appropriate. We thus attempt to estimate farm power populations by zone, to place them into the context of the asweddumised acreage and to estimate the proportion of land preparation attributable to each. This last exercise leads to questions of whether there is a farm power deficit, not to imply that part of the asweddumised acreage remains unploughed for lack of power, since in practice, the areas which are not tilled are left fallow for a variety of other reasons, (the chief of which is lack of a reliable water supply) but in the sense that there might be excessive delays in land preparation attributable to non-availability of power, and/or inadequacies in the quality of work done resulting from some need to spread the existing power stock too thinly.

V . I THE NATIONAL STOCK OF FARM POWER

1) BUFFALOW POPULATION

There exist at present two major sources of official statistics relating to the size of the national buffalo population, but the wide discrepancies they contain cast serious doubt on their reliability and usefulness for planning purposes. The first source is the Annual Livestock Population Survey conducted for the Department of Census and Statistics (D.C.S) based on the individual Grama Sevaka's (village headman) annual estimates of the livestock population for each particular area (Table VI.I).(referred to below as the Annual Survey). Since, the G.S.'s lack of interest in this annual survey is notorious, the estimates have, in official circles, been widely regarded as inaccurate, preference being given to the second major source of livestock data, the 1962 and 1973 Agricultural Censuses.(referred to below as the Census).

TABLE V .I: BUFFALO POPULATION

Year	Number ('000)		Year(cont'd)	Number(cont'd) ('000)	
1960	813		1970	736	
1961	772		1971	731	
1962	667	(596*)	1972	748	
1963	852		1973	711	(381*)
1964	1002		1974	736	
1965	1051		1975	818	
1966	832		1976	854	
1967	765		1977	796	
1968	783		1978	814	
1969	765		1979	844	

Source: Annual Livestock Population Survey, DCS.

* Census figures for the respective years.

According to the 1962 Census which was a national door-to-door survey, the buffalo population in that year was 596,000. The DCS Annual Survey estimate, for the same year, was 667,000. Since then the gap between the two estimates has widened, so that in 1979 the former, with a negative rate of change, was only approximately half the latter (showing a positive rate of change). Attempts to make forward projections of buffalo populations are thus beset by two problems: uncertainty regarding the appropriate base figure, and uncertainty in the selection of an appropriate rate of change.

At the most pessimistic extreme, the compound annual 4% rate of decline derived from the difference between 1962 and 1973 Census figures, will, when based on the 1973 Census figure of 381,000 buffalo, give a current 1980 population of 286,000. Using an alternative rate of decline of 0.7% adopted by the National Livestock Development Board (NLDB, 1979) gives a 1980 herd of 363,000. Table VI.2) At the most optimistic extreme, the Annual Survey figures show an increase in the population between 1973 and 1979, to give a 1979 figure of 844,000 buffalo.

TABLE V .2 BUFFALO POPULATION PROJECTIONS ('000)

	1962	1973	1974	1975	1976	1977	1978	1979	1980
1)	596	381							286
2)	596	381	378	376	373	370	368	365	363
3)	667	711	736	818	854	796	814	844	

Source: 1) Census base (1973) at 4% p.a. decline derived from 1962 and 1973 Census figure.
2) Census base (1973) with 0.7% p.a. decline derived from NLDB.
3) Annual Survey figures.

To decide on a "best estimate" for 1980 in view of such widely-divergent figures is not easy. There is, however, an increasing body of evidence which suggests that the Census base for 1973, and the 4% p.a. decline derived from its comparison with 1962, are excessively pessimistic.

The likelihood of underestimation of the buffalo populations by the Census may originate both in deficiencies in survey methodology and in the tendency of some herd owners, particularly in the free-grazing Dry Zone, to underestimate actual buffalo numbers. The evidence from recent studies certainly points to such an underestimate:

For instance, in a house-to-house census conducted recently by the NLDB in the Kuliyapitiya electorate in Kurunegala District a total of 10,070 buffaloes were counted, owned by 80451 persons. Since Kurunegala has a population of 1,159,000 persons, the total number of buffaloes in the entire district may be roughly deduced as 144,000. This compares fairly well with the population of 157,000 estimated by the Annual Survey in 1979.

A survey conducted by the Department of Animal Production and Health at Peradeniya within a number of Agrarian Service Centre areas similarly suggests that for some districts the Annual Survey estimate is a more reliable measure of actual livestock populations. In the head count conducted in ASC areas in Kurunegala and Anuradhapura Districts, average buffalo herd sizes were found to be far higher than those reported by the 1973 Census. The buffalo population for Kurunegala was estimated as 178,000 in comparison to 108,000 (1973 Census) and 157,000 (1979 Annual Survey). For Anuradhapura the survey estimate was 109,000 in comparison to 44,000 (Census) and 113,100 (1979 Annual Survey). Conversely, calculations for Galle and Matara Districts correspond more closely with the 1973 Census figures.
(pers. comm., E.M.Richards, FAO/Dept. Animal Production and Health).

On the basis of those considerations it is the opinion of the recent FAO Livestock Development Mission to Sri Lanka (January, 1980) that the present livestock population would be closer to the village headmen's figures given in the Annual Survey, although these are also considered unreliable.

Even at the most optimistic estimates of the 1980 buffalo population, some substantial reduction since the peak of the mid-sixties is evident. Much of this is accounted for by the growing demand for beef, which is the cheapest of meats available to consumers. Buffalo off-take rates are difficult to calculate since the slaughter of buffaloes is prohibited, forcing the activity to continue concealed. While the number of buffalo hides processed by the Ceylon Leather Products Corporation in 1978 and 1979 was 2,580 and 4,000 respectively, it is felt that the actual rate of slaughter is in excess of 20,000 head per annum (Burch, 1979). The shrink-

TABLE V.3 DISTRIBUTION BY DISTRICT AND AGRO-ECOLOGICAL ZONE OF THE BUFFALO POPULATION

Zone	District	Population 1979	Percentage distribution
Wet	1. Colombo	11,100	1.3
	2. Gampaha	28,000	3.4
	3. Kalutara	29,700	3.5
	4. Galle	13,500	1.6
	5. Matara	16,200	1.9
	6. Kegalle	27,700	3.3
	7. Ratnapura	31,600	3.7
	8. Kandy	30,700	3.6
	9. Nuwara Eliya	5,800	0.7
	Total	195,100	23.1
Intermediate	10. Kurunegala	157,000	18.6
	11. Matale	32,200	3.8
	12. Badulla	17,200	2.0
	Total	206,400	24.5
Dry	13. Puttalam	24,600	2.9
	14. Monaragala	14,100	1.7
	15. Jaffna	1,700	0.2
	16. Vavuniya	4,300	0.5
	17. Mannar	6,400	0.8
	18. Anuradhapura	113,100	13.4
	19. Polonnaruwa	53,900	6.4
	20. Trincomalee	43,600	5.2
	21. Batticaloa	39,800	4.7
	22. Mullaitivu	15,600	1.8
	23. Amparai	58,200	6.9
	24. Hambantota	66,900	7.9
	Total	442,200	52.4
	Sri Lanka Total	843,700	

Source: Annual Livestock Population Survey, 1979 (DCS) ing area of available grazing land and the spread of tractorisation in the rural sector as a substitute for, rather than a supplement to, buffalo draught power, particularly in the Dry Zone where over half the total herd is located, has also been a contributing factor to the reduction in the buffalo populatinn in the last decade and a half. On balance both the Annual Survey figures and the NLDB projections appear more realistic than extrapolations based on data drawn from the two Censuses.

DISTRIBUTION OF BUFFALOES

Table V .3 shows the district and zonal distribution of the buffalo population based on the 1979 DCS Annual Survey. Comparison of the distribution of the national herd according to agro-ecological zones with that of asweddumised land (Table V .14) suggests an imbalance in the spatial distribution of the island's buffalo population in relation to zonal draught power requirements. The Dry Zone accounts for 62.1% of asweddumised land but only 52.4% of the national herd. On the other hand the Intermediate Zone supports 24.5% of the buffalo population while accounting for 15.5% of the asweddumised area. Although from our work rate assumptions below (Table V .12) there are sufficient numbers of buffaloes to cultivate some 96% of all the asweddumised land, the tillage capabilities of the dry zone buffalo stock fall short of total requirements, although seem to comfortably exceed (by a factor of 2.4) the estimated Maha acreage prepared by buffalo in 1978/79 (Table V .14).

Until such time as the data base is considerably improved a reliable assessment of draught buffalo stocks in the rural sector will remain impossible. Without accurate and consistent livestock statistics the existence of power deficits and surpluses will be simultaneously argued according to the source of data chosen. The Highland Crops and Livestock Survey (1979/80) currently conducted by the DCS and the proposed 1981 Agricultural Census, along with a number of smaller scale surveys, might overcome some of the deficiencies in livestock data in the near future.

It is pertinent to record that neat cattle are also used, albeit on a limited scale, for land preparation in Sri Lanka. Their use is restricted to the drier parts of the country, such as the North and North-East provinces, where dry and semi-wet tillage is practised. There is an increased awareness of the potential of different breeds of bullocks in tillage operations (e.g.Sri Lanka Canada Dry Farming Project , the Tank Irrigation Modernisation Project)and whether this will lead to appropriate experimental work and more widespread use of them by farmers remains to be seen. As soon as more reliable and comprehensive data on the use of neat cattle for tillage becomes available planners will be able to include another important dimension in the national farm power mix.

2. TWO WHEEL TRACTORS

According to the Registrar of Motor Vehicles (RMV) compulsory registration of 2 wheel tractors (2 w.t.) started only in 1973. Table V . 4 shows the growth of annual registrations.

TABLE V .4 TWO-WHEEL TRACTOR REGISTRATIONS

Year	Number	Accumulative Total
1973	1,311	1,311
1974	1,864	3,175
1975	1,107	4,282
1976	780	5,062
1977	1,094	6,156
1978	2,273	8,429
1979	2,032	10,461

Source : RMV

While the possibility exists that a certain proportion of 2 w.t. are unregistered (e.g. of the 77 machines in the Farm Power Survey, 24 are unregistered) the import figures for the same period suggest that RMV data are not a gross misrepresentation of the available supply of this power type for agricultural and transport services in the country(see Table V .5).

Since 1970 a total of 12,156 two-wheel tractors have been imported, with nearly half of these arriving after the "liberalisation" of tractor imports in 1977 when the State Trading (Tractor) Corporation ceased to continue operating as the sole import agency.

The 1978/79 Seasonal Reports of the Assistant Directors of Agriculture calculate the size of the operational 2 w.t. fleet at 9,340 (Table V .10) while the Ministry of Agricultural Development and Research (MADR) estimates that there are 11,287 machines in the country, based largely on the findings of the Government Tractor Survey of 1974 (Burch 1979) with the addition of imports in subsequent years.

Assuming that the operational life of the average power tiller is six years, the available supply will comprise those imports since 1974, i.e. approximately 9000. This figure is supported by RMV registrations for the same period.

In order to calculate the number of 2 w.t. available to the small farm sector for seasonal land preparation and other agricultural activities, deductions have to be made for tractors employed solely in haulage work and in the estate sector, whether under government or private control. The 1974 Tractor Survey calculated that 95% of all serviceable 2 w.t. were used for agricultural purposes. This figure is generally regarded as over-optimistic, For the purposes of calculating the degree of availability of 2 w.t. for agricultural work the assumptions of 80% of the total fleet in the Wet and Intermediate Zones and 90% in the Dry Zone have been used (see Table V..5) on this basis, 7740 machines are estimated to be available for seasonal field cultivation. However, these estimates require cautious treatment since the markets for agricultural and non-agricultural tractor time are neither static nor at any given moment clearly defined.

The zonal distribution of 2 w.t. according to four different sources is given in Table V..6. Following this, for the purposes of calculating tractor densities in each zone (Table VI.13) we assume a distribution ratio of 25:15:60 between the Wet, Intermediate and Dry Zones respectively. However, due to the mobility of all tractor types (particularly 4 w.t.) between districts and zones in response to seasonal agricultural and related requirements, exercises designed to determine district/zonal power surpluses or deficits are of limited use.

Table V .5 TWO WHEEL TRACTOR IMPORTS 1970-1979

Year	Iseki	Kubota	Yanmar	Other	Total	Cumulative Total
1970	94	189	-	565	848	848
1971	550	850	-	-	1400	2248
1972	251	-	1	302	556	2804
1973	300	200	200	2	702	3506
1974	510	300	-	10	820	4326
1975	-	800	500	1	1301	5627
1976	-	-	-	-	-	5627
1977	3	1103	300	-	1406	7033
1978	48	3951	1050	1	5050	12083
1979	48	-	-	25	73	12156

Source: State Trading (Tractor) Corporation and other private tractor agents.

Table V .6 ZONAL DISTRIBUTION(%) OF TWO-WHEEL TRACTORS

Zone	1 Tractor Corporation	2 Agricultural Dev. Authority	2 1974 Tractor Survey	4 Assistant Director of Agr. Report
Wet	25.0	30.3	39.1	9.7
Intermediate	22.3	24.2	11.7	6.9
Dry	52.7	45.5	49.2	83.4

Notes : Column 1 - as reported in April, 1979
Column 2 - as reported in June, 1978
Both columns are drawn from personal communications with the FAO Farm Power Study Team.
Columns 3 and 4 from Table V .10.

3. FOUR-WHEEL TRACTORS

By the end of 1979 the number of four-wheel tractors (4 w.t.) registered in Sri Lanka since 1961 had reached 18,641. One possible method of calculating the size of the current operational fleet is to assume that on average the working life of each tractor lasts 10 years (10,000 hours at 1,000 hours per annum). RMV registrations for the period 1970-1979 totalled 9,128, with over 58% of these registered in 1978 and 1979. However given the improvement in the supply and distribution of spare parts during the last few years and the mechanical ingenuity found at repair centres throughout the island, the ten year lifespan of the 4 w.t is likely to be a pessimistic estimate.

Table V .7 FOUR WHEEL TRACTOR REGISTRATIONS

Year	Number	Cumulative Total	Year (cont'd)	Number	Cumulative Total
1961	986	986	1970	1223	10736
1962	1094	2080	1971	274	11010
1963	799	2879	1972	1006	12016
1964	507	3386	1973	155	12171
1965	300	3686	1974	192	12363
1966	1095	4781	1975	200	12563
1967	1792	6573	1976	310	12873
1968	1130	7703	1977	450	13323
1969	1810	9513	1978	2532	15853
			1979	2786	18641

Source: RMV

The volume of tractor imports over the last ten years (including also part of 1969) is given as approximately 10,000 in Table V .8. In contrast, the 1978/79 Seasonal Reports of the Assistant Director of Agriculture indicate the total 4 w.t. population as 6643 for all but one district, with the major share of those located in the Dry Zone. However, it is likely that the current fleet of serviceable tractors is best calculated from the RMV and import data, and is assumed to number 9500.

The zonal distribution of 4 w.t. is calculated in the ratio 20:20:60 between the Wet, Intermediate and Dry Zone respectively (Table V .9).

According to the 1974 Tractor Survey only 72% of the 10,151 four-wheel tractors were is working order (Table V .10), and of these 84% were employed in agricultural work in the small farm sector. The Survey was conducted at a time of severe spare parts shortages: with the improvement in spare parts availability and the higher proportions of new tractors in the total fleet and the percentage of tractors in working order is probably greater today.

The availability of 4 w.t. for field cultivation is influenced by the availability of, and rates paid for, alternative uses such as haulage. It is assumed that 50% of that part of the national fleet located in the Wet Zone is available for field cultivation there, 70% in the Intermediate

TABLE V. 8 IMPORTS OF FOUR WHEEL TRACTORS, 1966-1979

Year	Massey Ferguson	Ford	David Brown	I.M.T.	Harvester International	Russian	Other	Total	Cumulative Total
1966	833	167	-	-	50	-	4	1054	1054
1967	1293	333	-	-	210	-	128	1964	3018
1968	735	221	74	-	218	-	99	1347	4365
1969	1149	476	184	-	119	-	96	2024	6389
1970	445	120	-	-	-	-	70	635	7024
1971	876	-	-	-	-	-	-	876	7900
1972	124	-	-	-	-	30	4	34	7934
1973	-	-	-	-	-	-	2	2	7936
1974	-	-	-	-	-	31	100	131	8067
1975	101	-	-	-	-	-	2	103	8170
1976	20	5	-	-	-	104	1	130	8300
1977	453	283	-	201	106	200	9	1252	9552
1978	1652	406	40	-	100	-	5	2203	11755
1979*	1983	617	62	468	100	-	-	3230	14985

Source: State Trading (Tractor) Corporation and private tractor agents.

* (up to 15/2/80)

Zone and 80% in the Dry Zone, i.e. 6,840 machines in total (see Table V .10) This distribution is on estimate based on "observations and discussions with individuals and agencies associated with farm mechanisation "(FAO, 1980). The Dry Zone figure corresponds closely with the peak season distribution between agricultural and non-agricultural work observed from our data (3.2. above).

Table V .9 ZONAL DISTRIBUTION (%) OF FOUR WHEEL TRACTORS

Zone	1 Tractor Imports excluding Colombo 1973-'78.	2 Tractor Imports excluding Colombo 1978-'79.	3 Agricultural Divisional Authority, 1978.	4 Tractor survey 1974.
Wet	25.5	14.4	20.0	23.0
Intermediate	22.5	20.8	20.0	17.3
Dry	52.0	64.8	50.0	59.7

Source : Column 1 and 2 - Tractor Corporation
Column 4 - Table V .10.

Note : Columns 1, and 3 are quoted from personal communication with FAO FArm Power Study Team.

Table V .10. DISTRIBUTION OF 2 w.t. AND 4 w.t. BY DISTRICT AND ZONE

Zone	District	Two-Wheel(A) No.	Two-Wheel(A) %	Two-Wheel(B) No.	Two-Wheel(B) %	Four-Wheel(A) No.	Four-Wheel(A) %	Four-Wheel(B) No.	Four-Wheel(B) %
Wet	1.Colombo	387	10.8	149	1.6	780	7.7	31	0.5
	2.Kalutara	116	3.2	56	0.6	99	1.0	37	0.6
	3.Galle	183	5.1	72	0.8	146	1.4	20	0.3
	4.Matara	270	7.5	217	2.3	460	4.5	67	1.0
	5.Kegalle	40	1.1	n.a.	-	331	3.3	n.a	-
	6.Ratnapura	191	5.3	138	1.8	162	1.6	66	1.0
	7.Kandy	194	5.4	264	2.8	185	1.8	30	0.4
	8.N'Eliya	19	0.5	14	0.1	177	1.7	14	0.2
	Total	1400	39.1	910	9.7	2340	23.0	265	4.0
Inte-rmed-iate	9.Kurune-gala	220	6.1	471	5.0	1300	12.8	464	7.0
	10.Matale	65	1.8	96	1.0	215	2.1	104	1.6
	11.Badulla	134	3.7	76	0.8	239	2.3	68	1.0
	Total	419	11.7	643	6.9	1754	17.3	636	9.6
Dry	12.Puttalam	136	3.8	140	1.5	283	2.8	189	2.8
	13.Monera-gala	119	3.3	89	0.9	171	1.7	152	2.3
	14.Jaffna	123	3.4	266	2.8	866	8.5	1271	19.1
	15.Vavunia	32	0.9	31	0.3	617	6.1	519	7.8
	16.Mannar	24	0.7	28	0.3	453	4.5	1305	19.6
	17.A'dhapura	363	10.1	1091	11.7	773	7.6	659	9.9
	18.P'naruwa	83	2.3	2424	25.9	520	5.1	202	3.0
	19.Trinco-malee	96	2.7	2827	30.3	742	7.3	126	1.9
	20.Batti-caloa	26	0.7	15	0.2	671	6.6	408	6.1
	21.Amparai	159	4.4	35	0.4	526	5.2	661	9.9
	22.Hamban-tota	603	16.8	841	9.0	435	4.3	250	3.8
	Total	1764	49.2	7787	83.4	6057	59.7	5742	86.4
SRI LANKA TOTAL		3583	100.0	9340	100.0	10151	100.0	6643	100.0

Source A: Findings of Government Tractor Survey, 1974, Ministry of Agriculture and Lands (quoted from D.Burch, 1979)

B: 1978/79 Seasonal Reports fo the Assistant Directors of Agriculture, Department of Agriculture, Peradeniya.

Table V.11 PERCENTAGE OF ANNUAL PADDY ACREAGE BY POWER SOURCE FOR LAND PREPARATION

Zone	Mammoty	Animals	Tractors
	%	%	%
Wet	47.8	41.8	10.4
Intermediate	6.8	63.3	29.9
Dry	3.7	26.4	69.9
Sri Lanka	17.9	37.3	44.8

Source : Department of Agriculture, Peradeniya. Calculated as an average over four seasons i.e. Maha and Yala in 1977/78 and 1978/79.

Table V..12 THE EFFECTIVE AVAILABILITY OF DRAUGHT POWER BY TYPE AND BY ZONE.

		Total supply	% available for cultivation	Effective No. of units available for cultivation
Wet Zone	Buffaloes	195100	40	39020
	2 w.t.	2250	80	1800
	4 w.t.	1900	50	950
Intermediate Zone	Buffaloes	206400	40	41280
	2 w.t.	1350	80	1080
	4 w.t.	1900	70	1330
Dry Zone	Buffaloes	442200	40	88440
	2 w.t.	5400	90	4860
	4 w.t.	5700	80	4560
Sri Lanka	Buffaloes	843700	40	168740
	2 w.t.	9000	86	7740
	4 w.t.	9500	72	6840

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 Modernization Project Characteristics of Existing Tractor Operations, " Jan. 1979.

Tractors - Personal communication with FAO Farm Power Study Team.

4. POWER DENSITIES IN RELATION TO ASWEDDUMIZED LAND

Table V .13. POWER DENSITIES - PER THOUSAND ACRES OF ASWEDDUMIZED LAND 1979/80

Zone	Buffalo Pairs No.	Buffalo Pairs Density	2 Wheel Tractors No.	2 Wheel Tractors Density	4 Wheel Tractors No.	4 Wheel Tractors Density
Wet	39020	103.2	1800	4.8	950	2.5
Intermediate	41280	157.9	1080	4.1	1330	5.1
Dry	88440	84.5	4860	4.6	4560	4.4
Sri Lanka	168740	100.1	7740	4.6	6840	4.1

Note: Densities refer to draught power units available for field cultivation - see Table V . 12.

In Tables V .10 - V .13 we summarise existing data on power distributions by District and Zone, and estimate the effective availability of farm power by Zone and the effective densities of power per thousand acres of asweddumized land.

Some interesting differences are revealed when the density figures in Table V .13 are compared with the power densities obtained in each of the Dry Zone study locations (Tables 8 - 15). It must be borne in mind that the study locations are all major irrigation schemes, and are likely to have favourable power densities. The aggregate average of 4.4 four-wheel tractors recorded for the Dry Zone conceals considerable district-wise variation in the distribution of tractor population per thousand acres of asweddumized land within the zone. Densities of 4 w.t. at Padaviya and Minneriya are well in excess of the zonal average, while Uda Walawe and Kaudulla are roughly half. The study location densities do not include tractors located outside the schemes which contribute a significant portion of their activities to on-scheme work.

It is estimated that there are 4.6 two-wheel tractors in the Dry Zone per thousand acres. Only Kaudulla evidences a similar concentration of such tractors; the remaining locations have tractor densities well above the average. Buffalo densities are not directly comparable: by halving the study location figures for adult buffaloes the draught herd is obtained, and the halving of this provides the number of draught pairs. The Intermediate Zone average reflects the concentration of much of the national herd in this area, particularly in the Kurunegala district.(Table V .3). Again, figures from the study locations of 152 pairs at Padaviya, 75 at Kaudulla, 66 at Uda Walawe and 55 at Minneriya are spread on both sides of the Dry Zone average, which is both a moderately reassuring degree of compatibility between data from different sources, and an indication of the wide range which the Dry Zone average conceals.

The estimation of the island's power requirements based on the simple arthmetic of each zone's aggregate power supplies can lead to the misallocation of future resources to districts and schemes unless the zonal densities are disaggregated sufficiently to reveal the precise variations in local scheme and tract level power concentrations. The data displayed in the two power density tables indicate the extent to which a national or zonal average conceals locational variations.

5. A SHORTAGE OF POWER?

Working from the assumed work - rates and effective population densities of farm power (Table V .12) we can now estimate very broadly the tillage capacity of the effective stock, and relate it to the tillage patterns reported by Agriculture Department Officials.(Table V .11). This is done in Table V .14).

Both the methodology (taking as static what is an essentially dynamic market for power time) and the detailed assumptions underlying exercises of this type are questionable. For instance, a strong source of potential error lies in the estimated work-rates of power-types. Whilst we accept the FAO (1980) rates for 4 w.t. and 2 w.t., our estimates of buffalo populations are higher, and our tillage capacities are based on a potential of 0.3 acres/pair/day (Table V .12) as against their's of 0.156 acres/pair/day. Thus the buffalo tillage capacity that we estimate is larger than the FAO estimate. The higher work rate is extracted from observations by Parker (1978) in an area where buffaloes are used extensively with ploughs, a technique likely to give higher performance than the " tampl-ing" technique observed in some other areas. Analysis of data currently being collected will shed light on whether the typical Dry Zone performance corresponds more closely with one assumption than with the other.

Similarly, by contrast to the figures displayed in Table V .11, Pillanayagam (mimeo, undated) shows from field trials data that a 4 w.t. using a 9 - tine tiller for wetland tillage operates at between 50% and 80% field efficiency. With a potential capacity of 0.7 acres per hour, actual output lies in the range 0.35 - 0.56 acres/hour i.e. a 4. w.t. is capable of ploughing one acre of land in 1.8 to 2.8 hours. For 2 w.t., one acre of land can be ploughed in 6.2 to 7.1 hours using a rotavator under wetland conditions. For 4 w.t. this is significant improvement on the assumed rates used in Table V .12 and nearby doubles the total 4 w.t. tillage capability in each zone.

Again, the FAO team relied heavily on <u>assumptions</u> of use-levels of Farm Power. Our early data analysed in Section 3.2 suggest that buffalo and tractor resources are being used at far below potential levels. Based on a 20-week period covering the entire maha land preparation season, 4 w.t. were found to work an average of 14.5, 11.9 and 15.2 hours per week at Uda Walawe, Kaudulla and Padaviya respectively for all operations (the time devoted to agricultural work was 32%, 53% and 79% of total time respectively). Annual usage rates projected from these figures fall significantly below the FAO assumption of 1000 hours of operational time per annum, the highest extrapolation being 790 hours and the lowest 619 hours. Since the observed usage data are drawn from the busiest time of year, it is likely that even these extrapolated figures are overestimates. Two-wheel tractors recorded weekly use-intensities at the three locations of 13.3, 11.3, and 16.4 hours, approaching more closely their assumed operational life of 800 hours per annum. Buffalo usage per pair averaged nearly 7 hours per week.

The much lower use-intensities observed from our preliminary data analysis will radically alter the profitability of tractor ownership calculated on the basis of the FAO assumptions, if assumptions regarding other aspects of the costs and returns equation are accepted as valid. This is an issue which cannot be analysed in depth until more data are available from current field work. For the present purpose of estimating tillage capacities, low tractor use-intensities do not necessarily imply that assumptions regarding seasonal tillage capacities are incorrect. The assumptions used both by FAO and by ourselves of 21.8 acres/season/2 w.t. and 65 acres/season/4 w.t. (cf. Table V .11) may remain broadly correct, but the necessary time period for each power unit to cultivate these acreages may be much longer than has hitherto been thought. It may be nearer a 50-day land preparation period than the 32.5 days assumed. Indeed, there already exists some evidence to suggest that the land preparation season is nearer two months than one month in duration in many locations (TIMP, pers. comm; Cropping Systems Study, pers. comm.) The implications of this low tractor use-intensity and corresponding delays in tillage (and wastage of stored water) form a central issue in the present research and will be discussed in depth in a later report.

Nevertheless, whilst accepting that the figures in Table V .14 are broad estimates, some interesting trends emerge: first, the estimated capacity of each power type exceeds the area it is reported to have tilled in 1979/80 in both Wet and Intermediate Zones, i.e. there appears to be a surplus capacity of farm power in these zones as far as the requirements of the small farm sector are concerned. In the Dry Zone, on the otherhand, this is true of only the resident buffalo population. For mammoty cultivation, the difference is small, and reflects perhaps the seasonal migration of casual labour from Wet and Intermediate to the Dry Zone(c.f. Crooks and Ranbanda, forthcoming). A similar migration of 4 w.t. has been reported informally to the study team, and could account for part of the apparent gap between 4 w.t. capacity and area ploughed in the Dry Zone.

In conclusion, it would be unwise to rely too heavily on the results of analysis of data which is of such dubious validity as that considered in this Appendix. Tentatively, we would suggest that any "power gap" hypothesised from such data (by FAO and others) is likely to be more apparent than real. At the aggregate national level, estimated tillage capacities do not differ widely from reports of areas actually cultivated (Table VI.14), and there is no evidence that absence of farm power actually prevents cultivation of asweddumised land. We accept that it might delay cultivation, but would submit, as we argued in Chapter 3 above, that this is largely a result of problems in the organisation of power use, and of low use-levels. It would be desirable to raise use-levels for many reasons, particularly those relating to the returns obtained from capital (3.3 above) and so the problem seems to lie in the very low use-intensity of existing power stocks, not in any shortage of the number of power units.

TABLE V .14 TILLAGE CAPACITIES AND POWER REQUIREMENTS BY ZONE

Zone	Wet	Intermediate	Dry	Sri Lanka
1. Asweddumized area (1978/79, acres)	377975	261399	1046226	1685600
% distributinn	22.4	15.5	62.1	100
2. Estimated acreage prepared in Maha 1978/79 by				
i) Mammoty	152112	16224	48974	217310
ii) Buffalo	148672	151832	349853	650357
iii) Tractor	40049	79859	583986	703894
Total	340833	247915	982813	1571561
3. Estimated Maha tillage capabilities in acres of:				
i) Mammoty	171415	16858	35733	224006
ii) Buffalo	374592	396288	849024	1619904
iii) 2 Wheel tractor	39195	23517	105826	168538
iv) 4 wheel tractor	61750	86450	296400	444600
Total	646952	523113	1286983	2457048
4. Power "Surplus"	268977	261714	240757	771448

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

APPENDIX VI

POWER USE-INTENSITY AND HIRE CHARGES

In section 3.3 above, it was suggested that there is no urgency to generate rapid returns to investments in farm power at either the national or the individual level, primarily because of lack of competing investment opportunities in capital goods. What we did not examine there is the relationship between net returns (over running costs), use-levels and hire charges. The level of hire charges is a critically important component of power owners' and farmers' budgets, and can be hypothesised to be related to use-levels. The relationship is discussed below.

As suggested in 3.3 above, let us assume that power owners can broadly be divided into two categories: those who have purchased power on credit and wish to generate rapid returns primarily in order to meet repayment obligations and, second, those who have no such obligations and are content to generate returns over a longer period. The two groups can be conceptualised in terms of the asset-life attributed by each group to the power unit - the former wishing to recoup fixed costs over, say, a 5 - year life, the latter being content to spread fixed costs over, say, 10 years. Clearly, the annual volume of "profit" (i.e. over running costs) necessary to recoup fixed costs will be smaller for the latter than for the former, though not in the same ratio as the respective working lives because, by reducing annual revenue streams to a Net Present Value, annual profits earned in years 6-10 will be more heavily discounted than those earned in 1-5.

Annual profit over variable costs may be assumed to be a linear function of hours worked. It is true that the net returns per hour worked will vary according to operation, so that aggregate net returns will be influenced by the operation - mix, but the hire charges within operations and locations are observed to be relatively constant, so the assumption is likely to be broadly correct. If this is the case, then clearly the owner recouping over 10 years will work the same hours p.a. at a lower "profit"/ hour, or fewer hours at the same "profit"/ hour, or at some point between these two extremes. We can safely assume that variable costs per hour worked are unlikely to vary between the two types of owner, and if, as we suggest, hire charges are also similar, then the evidence strongly suggests that owners practising low use-intensity will fall at the low hours/high profit end of the previously mentioned spectrum. In other words, the preliminary observation of uniform hire charges within operations and within locations suggests that low-intensity owners are not using the competitive edge that their lower annual fixed costs would give them, but instead are following the prices set by high-intensity users and simply working the minimum number of hours necessary to achieve what they perceive as their necessary annual return on capital.

Thus, whilst credit-purchase schemes suggested themselves as a means of achieving higher use-intensities in 3.3 above, it is likely that their introduction at a specific location where they did not previously exist will cause an all-round increase in hire-charges, since those owners who did not purchase on credit terms and who do not therefore have any incentive to offer lower hire charges to gain more work, will simply follow the price-leaders. There may be specific exceptions to this generalisation, such as locations without credit-purchase schemes where, nontheless, hire charges are fixed by reference to areas which do have such schemes. As a general point, however, credit purchase may be seen as a mechanism for more adequately satisfying use-level requirements dictated by the international cost of capital, but at the expense of the farmer.

A brief note on animal-power charges may also be in order: Preliminary observations and data presented in Farrington and Abeysekera (1979) and Farrington et al (1980) suggest that buffalo hire charges are increased to follow increases in tractor hire charges caused by increasing fuel and capital costs. Since the life of buffalo assets is pre-determined and practically uniform, and the decision on whether to invest in them is based on some concept of the likely annual return over the maintenance costs from a given minimum volume of work, it follows that the possibility of increasing hire-charges in this way, in step with tractor charges, but always slightly lower so as to retain the necessary minimum volume of work, will, insofar as maintenance costs do not rise in the same proportion (and casual observations suggest that they do not) represent a windfall gain to buffalo owners. A priori arguments and casual observations suggest that this is the case. The most obvious solution but one running counter to current trends in farm power policies in Sri Lanka, and one which is only achievable on a large scale in the medium-term, is to increase buffalo populations or the use-intensities obtained from existing animal stocks by better implements etc. in the hope that competition for work will increase and hire-charges fall.

APPENDIX VII

PUBLISHED AND UNPUBLISHED WORK INVOLVING THE STUDY TEAM

PUBLISHED OR FORTHCOMING PAPERS

Farrington, J. (1979) & Abeysekera, W.A.T.	Issues in Farm Power and Water Use in Sri Lanka. Occasional Publication No. 17, ARTI, Colombo.
Farrington, J. (forthcoming) Ryan, M.J. Abeyratne, F. Bandara, S. (Mrs.)	Energy in the Small Farm Sector in Sri Lanka. Proceedings of Seminar on <u>Energy in Sri Lanka</u>, Sri Lanka Association for the Advancement of Science, Colombo. January, 1980.
Farrington, J. (forthcoming) Ryan, M.J. Abeyratne, F. Bandara, S. (Mrs.)	Draught Power for Small Farmers - A Critique of Planning Methodologies in Sri Lanka. Journal of Agrarian Studies, Colombo.
Fieldson, R.S. (1980) & Farrington, J.	Labour Supply for Small Farm Development in the Dry Zone. Paper presented at ARTI Seminar : <u>Research, Development and Rural Workers</u> 25-4-80 Colombo.
Moore, M.P. (forthcoming)	Approaches to Improving Water Management on Large-scale Irrigation Schemes in Sri Lanka. Draft submitted to ARTI.
Ryan, M.J. Abeyratne, F. Farrington, J.	Utilization of Buffaloes for Farm Power in Sri Lanka. Presented at Workshop on <u>Water Buffalo Research in Sri Lanka,</u> Peradeniya, November 1980.

INTERNALLY - CIRCULATED PAPERS

Farrington, J. Sociological Issues. Typescript, 1979.

Farrington, J. Sociology questions relating to Water - Some rough notes. Typescript, 20-12-79.

Farrington, J. Some thoughts on supposed "power shortages". Typescript, 21-3-80.

Moore, M.P. Report on a field trip to Kaudulla and Padaviya Irrigation Schemes. 26/3-4/4/80. Mimeo, 6-4-80.

Moore, M.P. Scenarios for Changes in Water Management Practices in Sri Lanka and their Interactions with Farm Power Use. Mimeo, May 1980.

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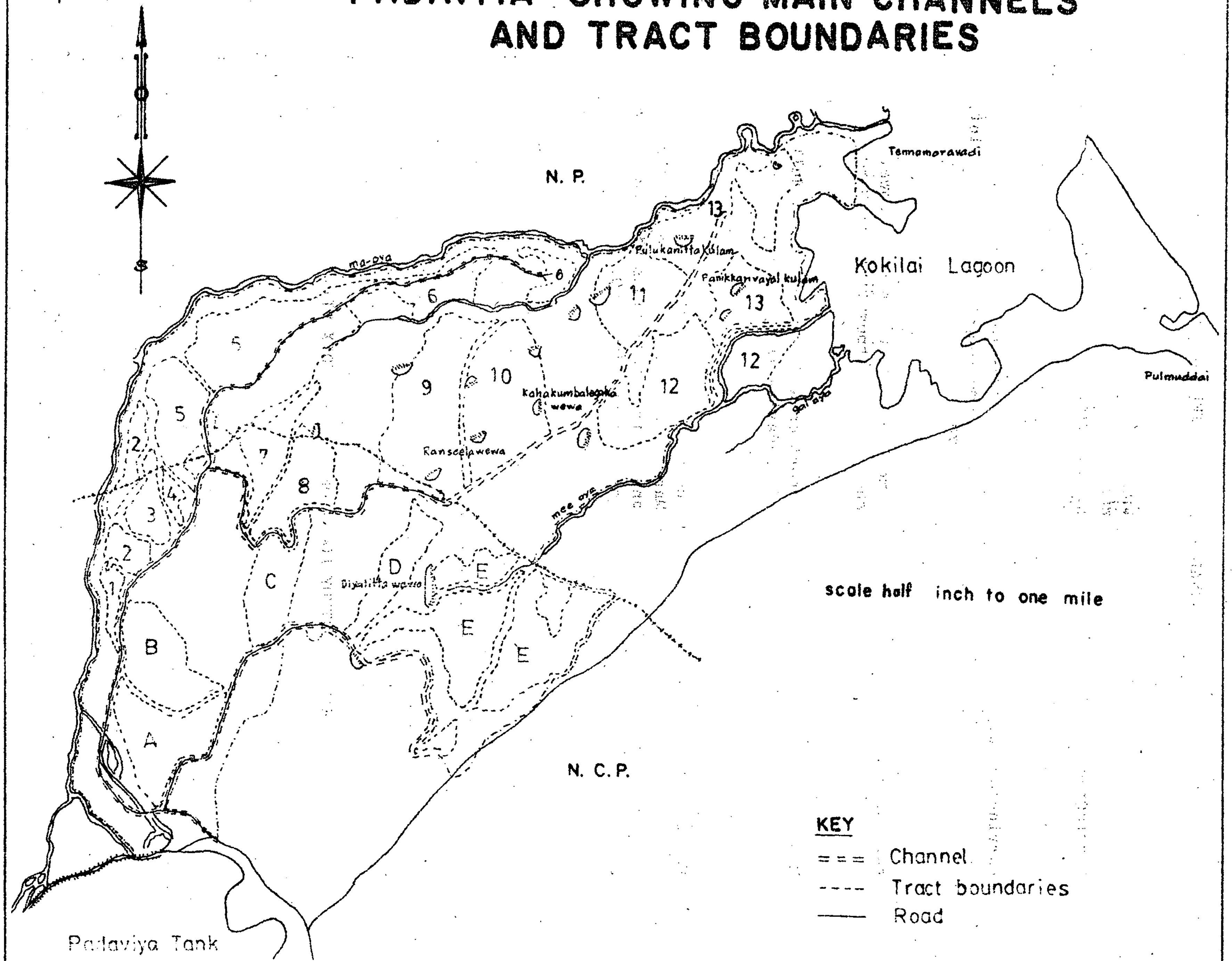
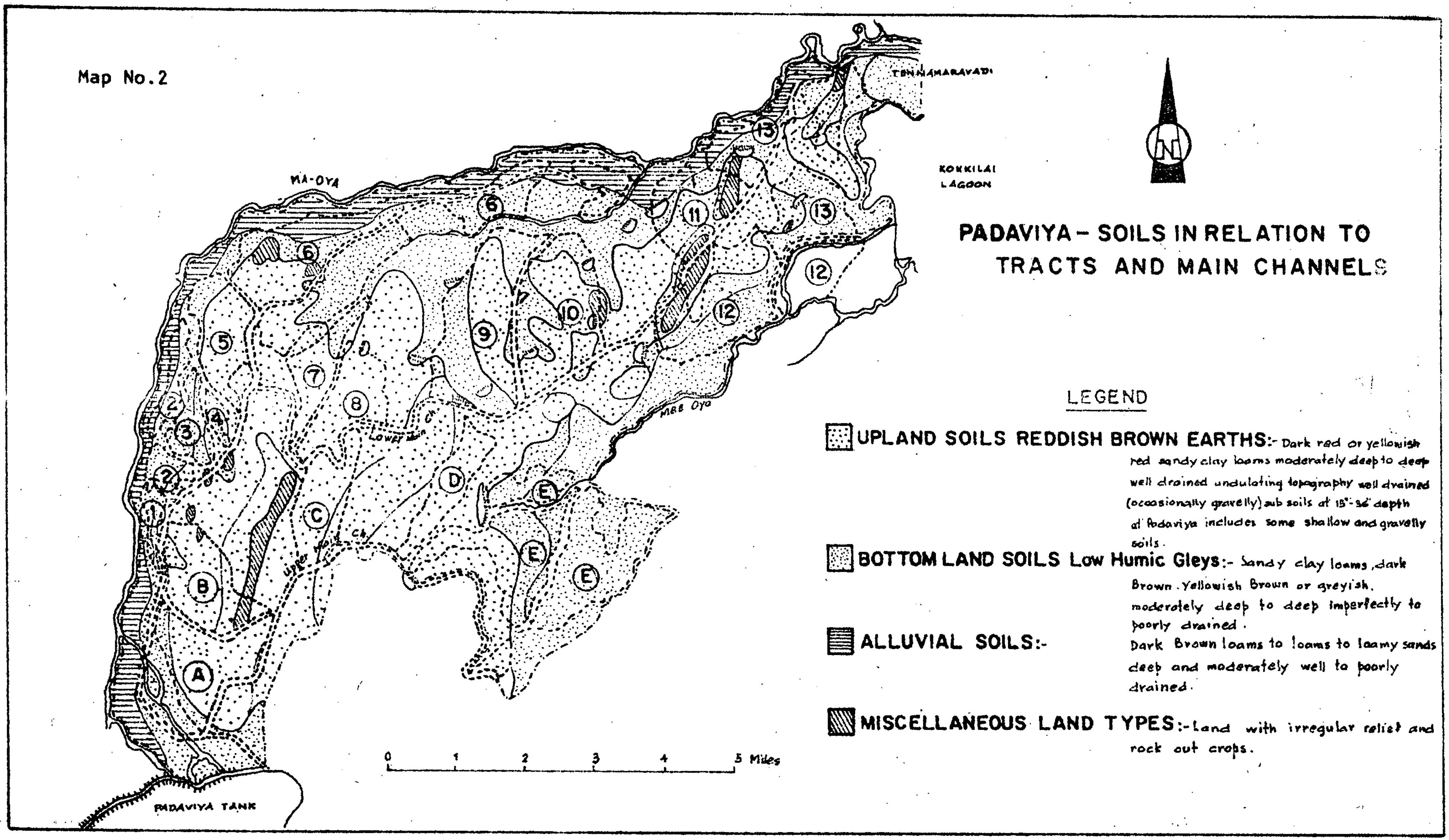
MAPS OF STUDY LOCATIONS IN APPENDIX VIII

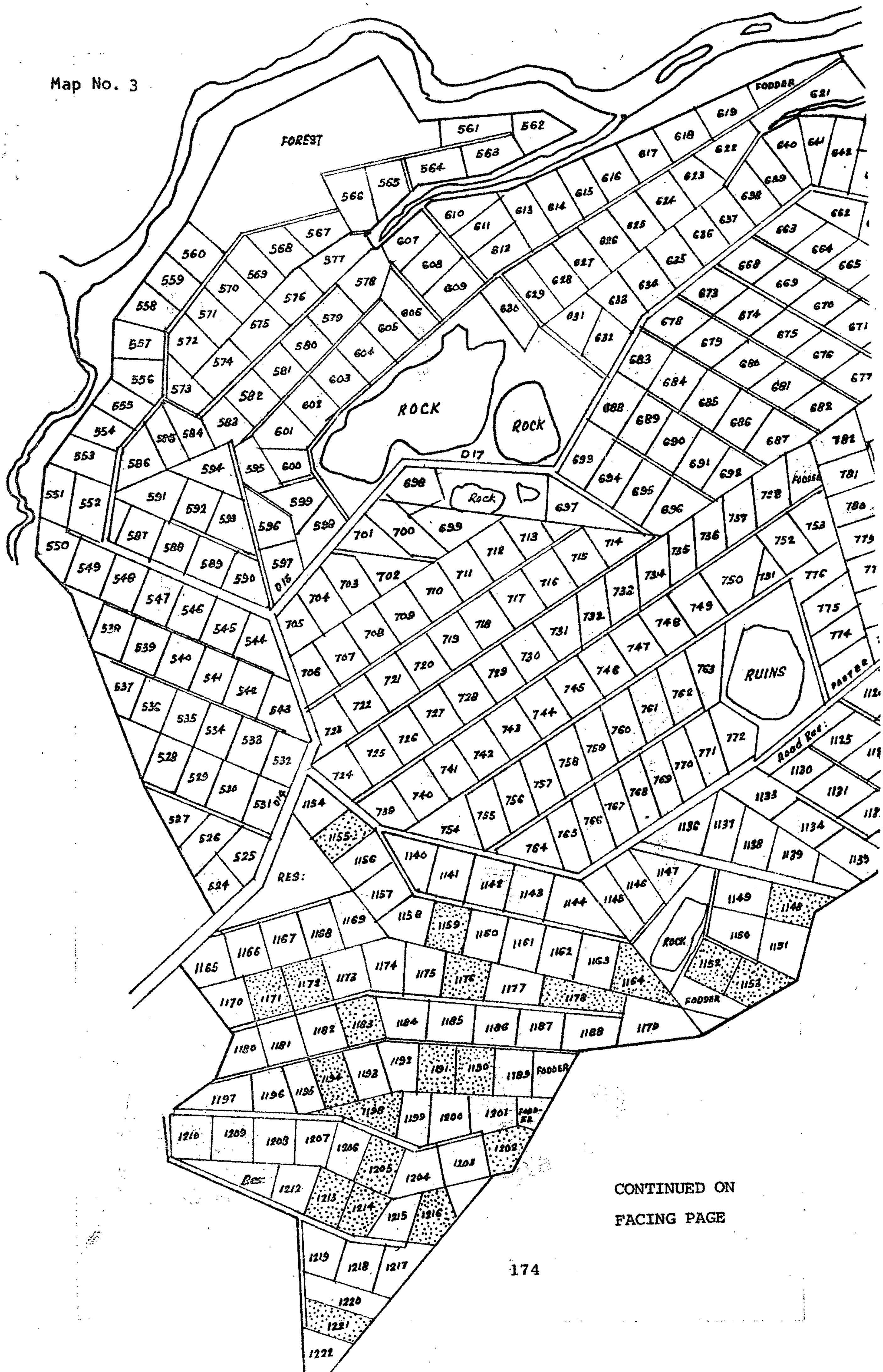
Map No.1

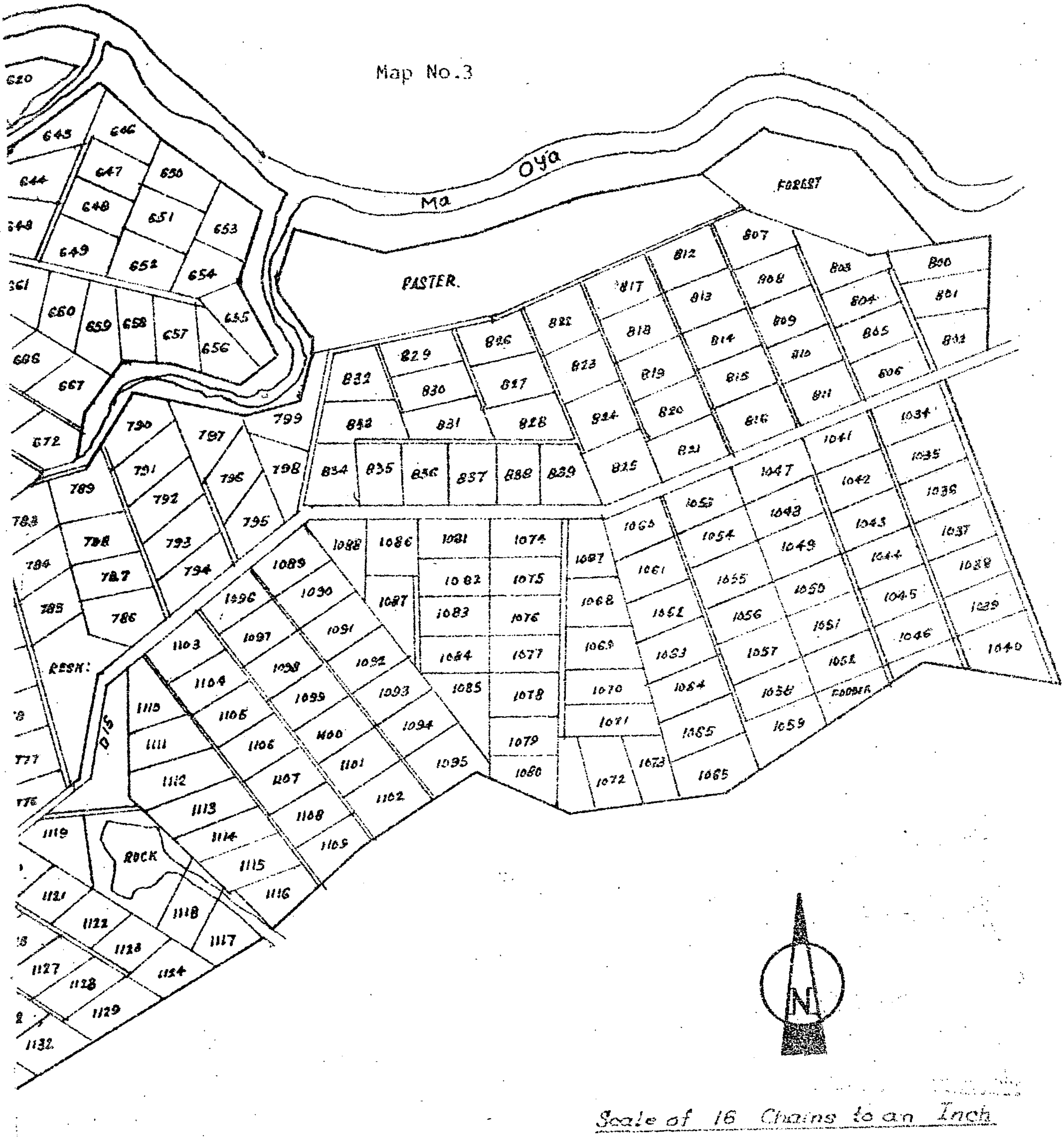
PADAVIYA- SHOWING MAIN CHANNELS AND TRACT BOUNDARIES




Map No. 2
PADAVIYA – SOILS IN RELATION TO TRACTS AND MAIN CHANNELS
MA-OYA
TENNAMARAVADI
KOKKILAI LAGOON
MEE OYA
PADAVIYA TANK
0 1 2 3 4 5 Miles
LEGEND
UPLAND SOILS REDDISH BROWN EARTHS:- Dark red or yellowish red sandy clay loams moderately deep to deep well drained undulating topography well drained (occasionally gravelly) sub soils at 15"-36" depth at Padaviya includes some shallow and gravelly soils.
BOTTOM LAND SOILS Low Humic Gleys:- Sandy clay loams, dark Brown. Yellowish Brown or greyish, moderately deep to deep imperfectly to poorly drained.
ALLUVIAL SOILS:- Dark Brown loams to loams to loamy sands deep and moderately well to poorly drained.
MISCELLANEOUS LAND TYPES:- Land with irregular relief and rock out crops.

Map No. 3


FOREST
ROCK
Rock
Rock
RUINS
ROCK
RES:
Res:
FODDER
Road Res:
D17
D16
CONTINUED ON
FACING PAGE



EXISTING BOUNDARIFS OF PADDY ALLOTMENTS IN TRACT-6, PADAVIYA

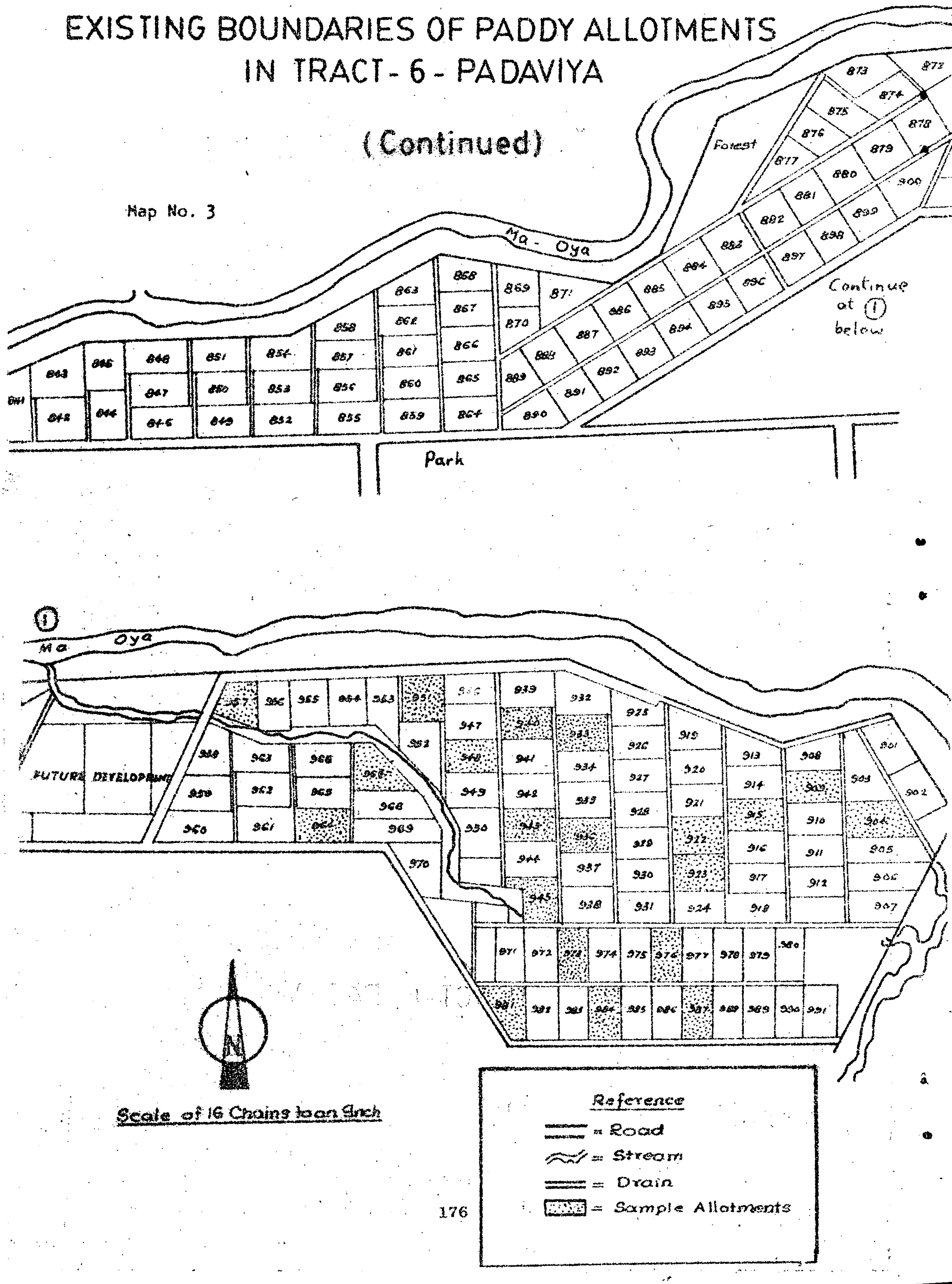
REFERENCE

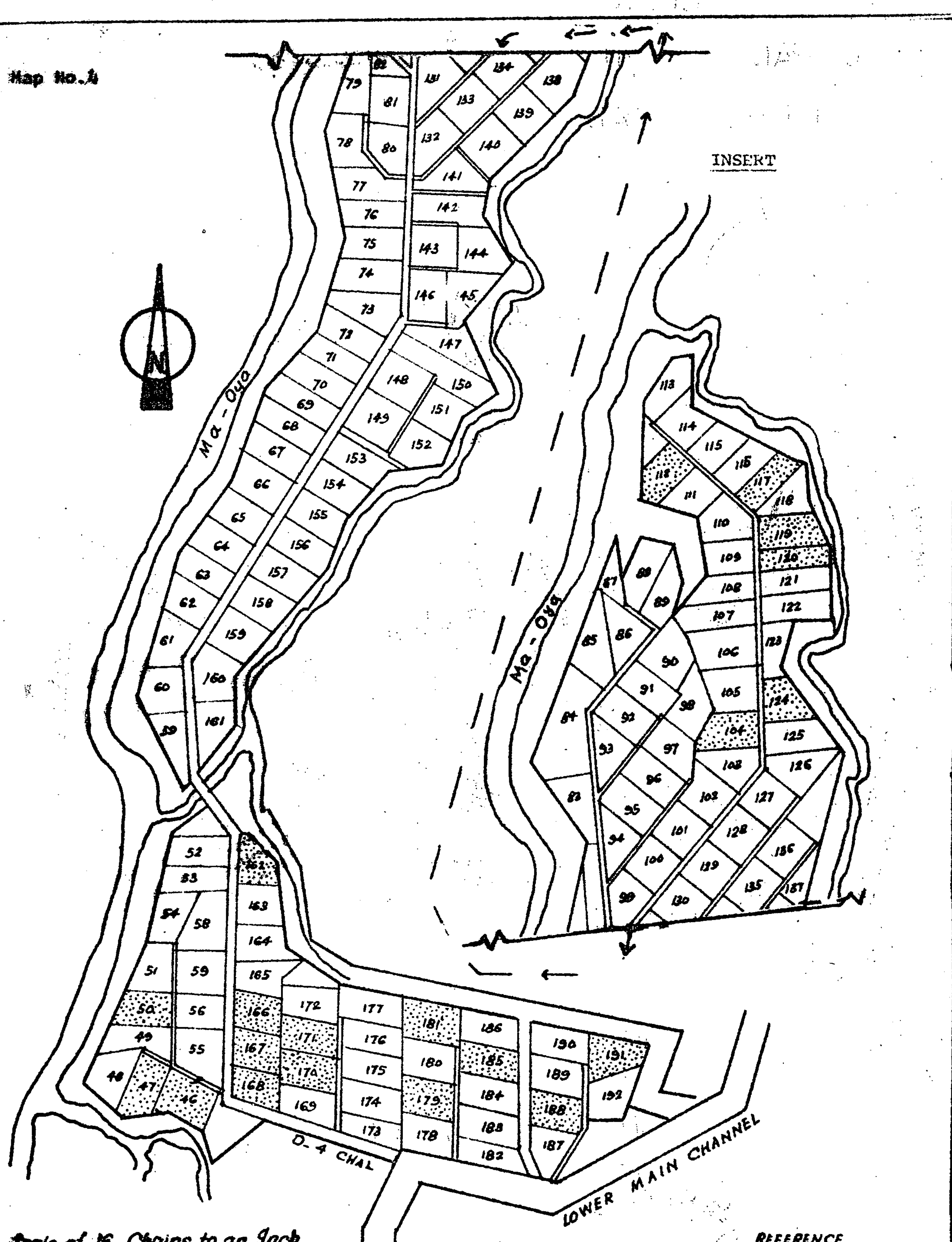
- = Road
- = Stream
- = Drain
- = Channel
- = Sample Allotments

EXISTING BOUNDARIES OF PADDY ALLOTMENTS IN TRACT - 6 - PADAVIYA

(Continued)

Map No. 3



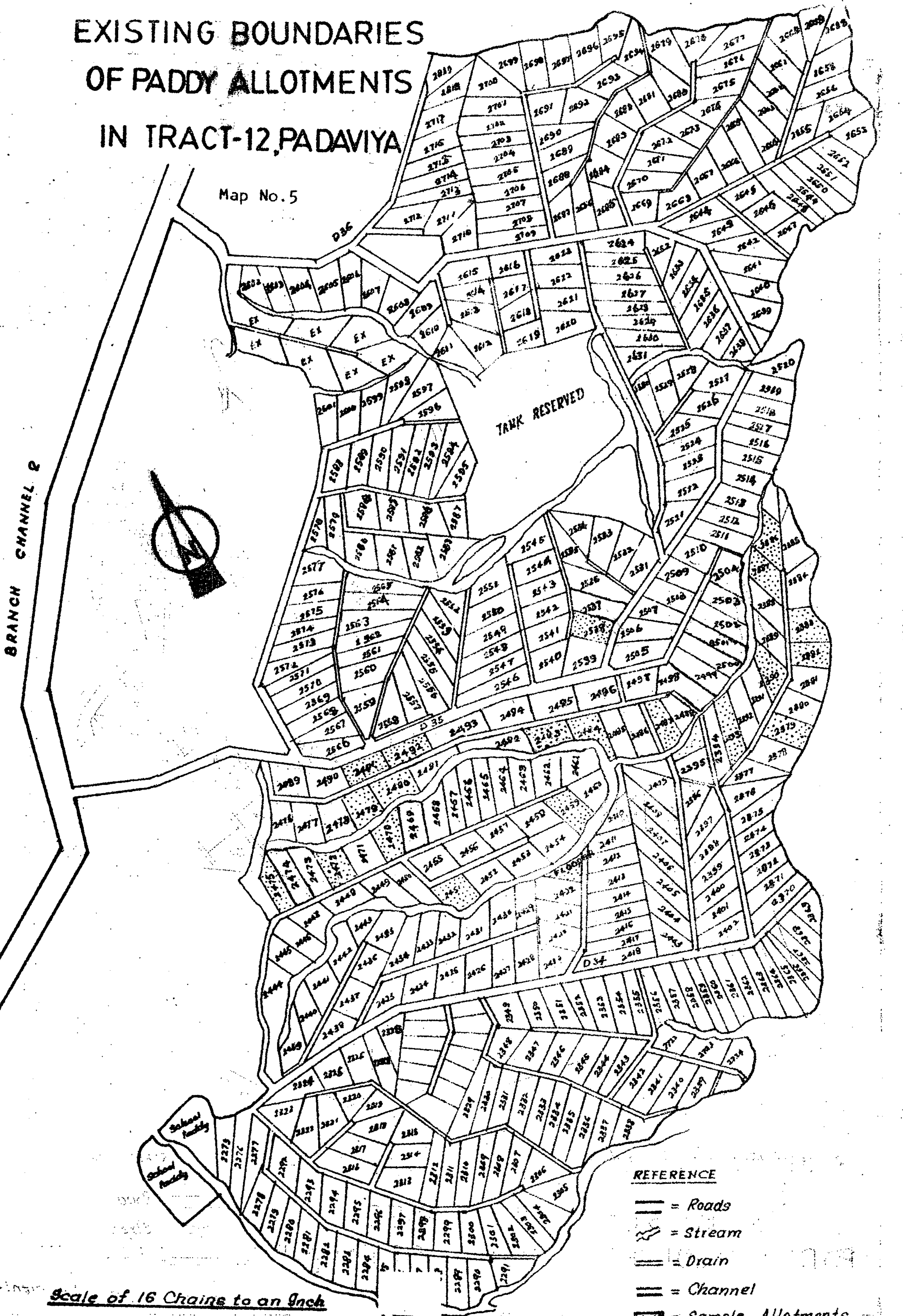


EXISTING BOUNDARIES OF PADDY ALLOTMENTS IN TRACT-2, PADAVIYA.

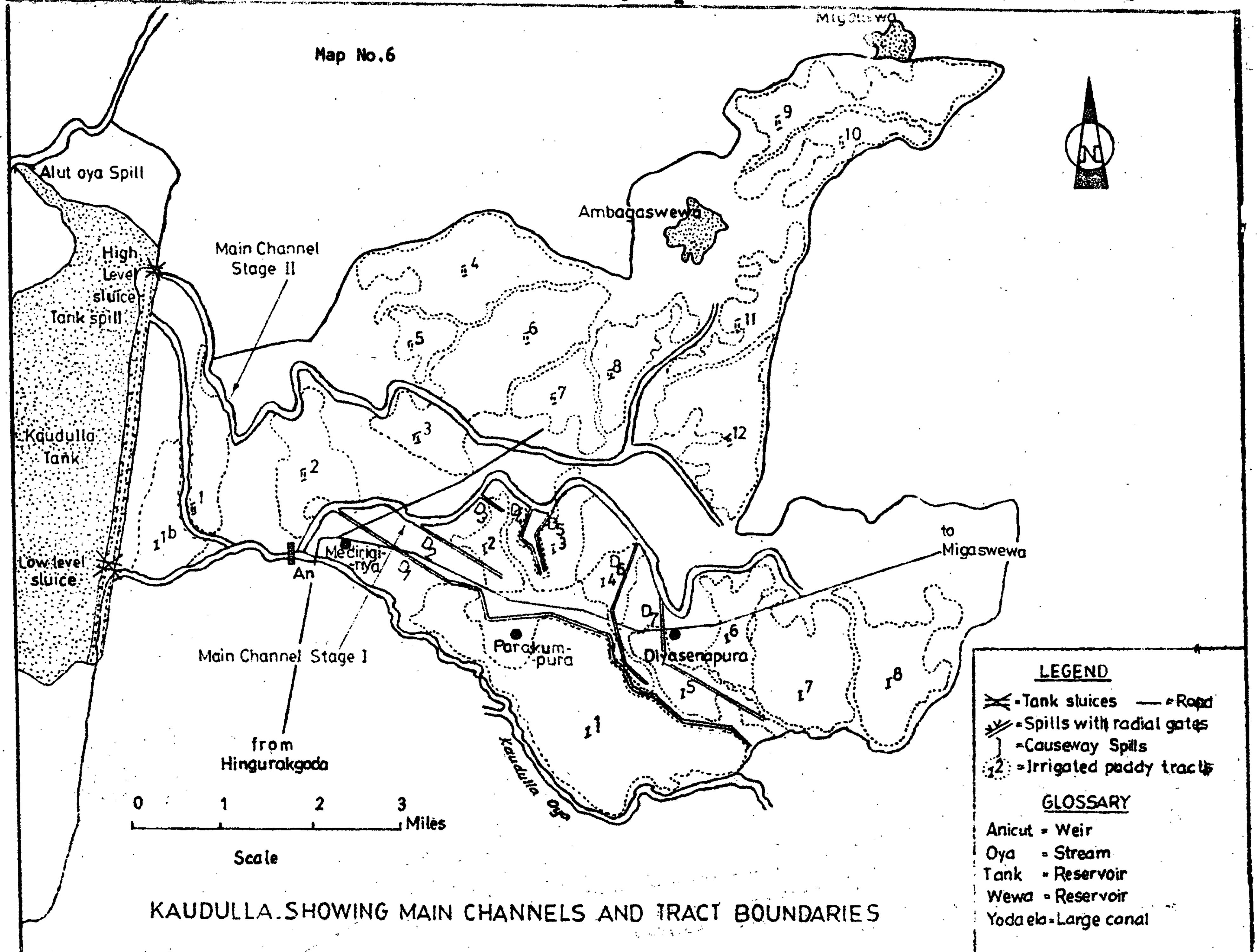
REFERENCE

= Roads
= Stream
= Drain
= Sample Allotments

EXISTING BOUNDARIES OF PADDY ALLOTMENTS IN TRACT-12, PADAVIYA



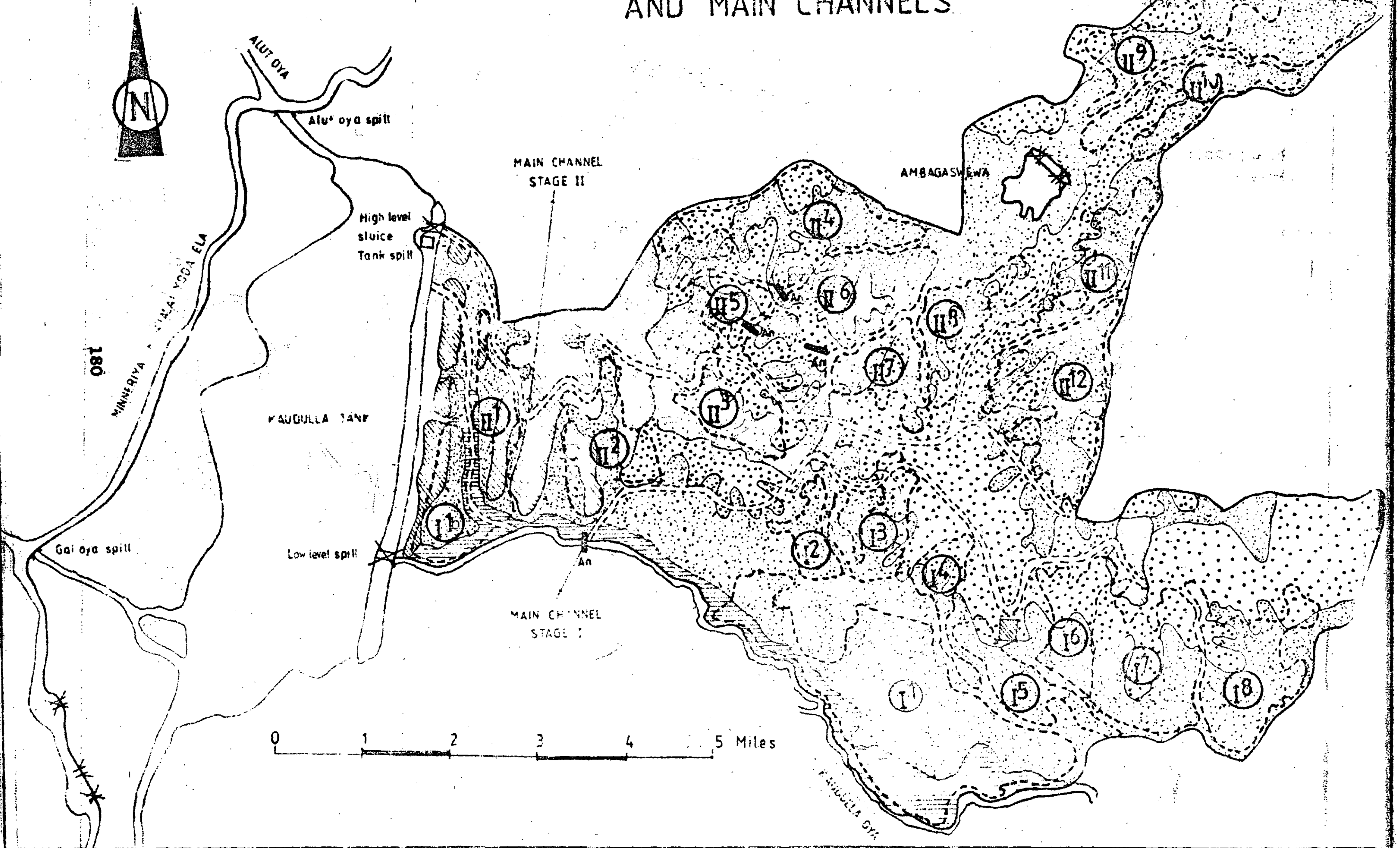
Scale of 16 Chains to an Inch



KAUDULLA. SHOWING MAIN CHANNELS AND TRACT BOUNDARIES

Map No. 7

KAUDULLA - SOILS INRELATION TO TRACTS AND MAIN CHANNELS



Map No.7

LEGEND

UPLAND SOILS (REDDISH BROWN EARTHS) :- Dark red yellowish, red sandy clay loams, moderately deep to deep well drained undulating topography well drained (occasionally gravelly) sub soil at 15"- 36" Depth.

BOTTOM LAND SOILS (LOW HUMIC GLEYS):- Sandy clay loams dark brown yellowish brown or greyish moderately deep to deep imperfectly to poorly drained.

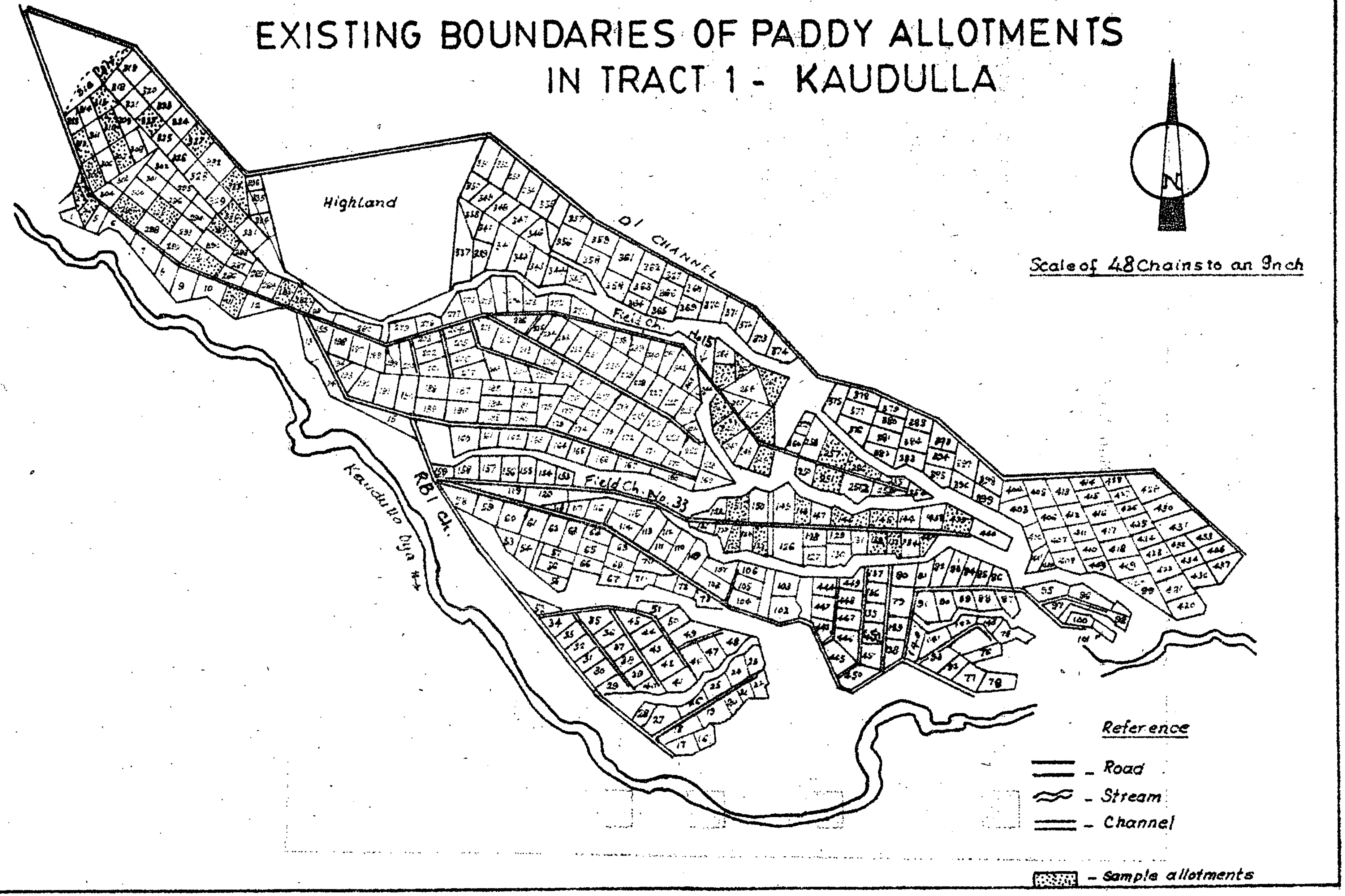
ALLUVIAL SOILS :- Dark brown loams to loamy sands, deep and moderately well to poorly drained

MISCELLANEOUS LAND TYPES :- Land with irregular and rock out crops

Source-Hydraulics Research Station / Institute of Hydrology (UK) Department of Irrigation Joint Study on Water Balances at Ka[illegible]la.

Map No.8

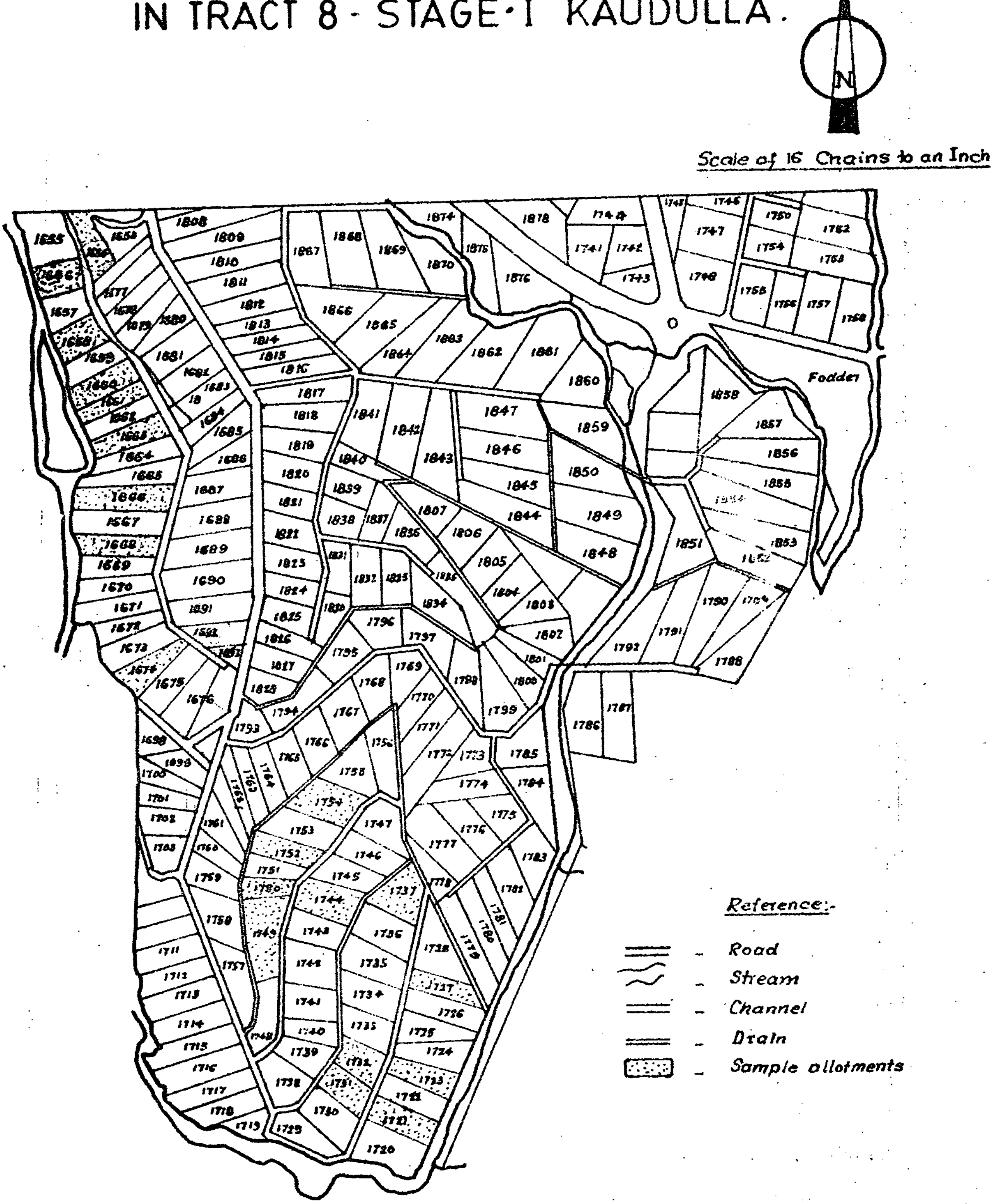
EXISTING BOUNDARIES OF PADDY ALLOTMENTS IN TRACT 1 - KAUDULLA

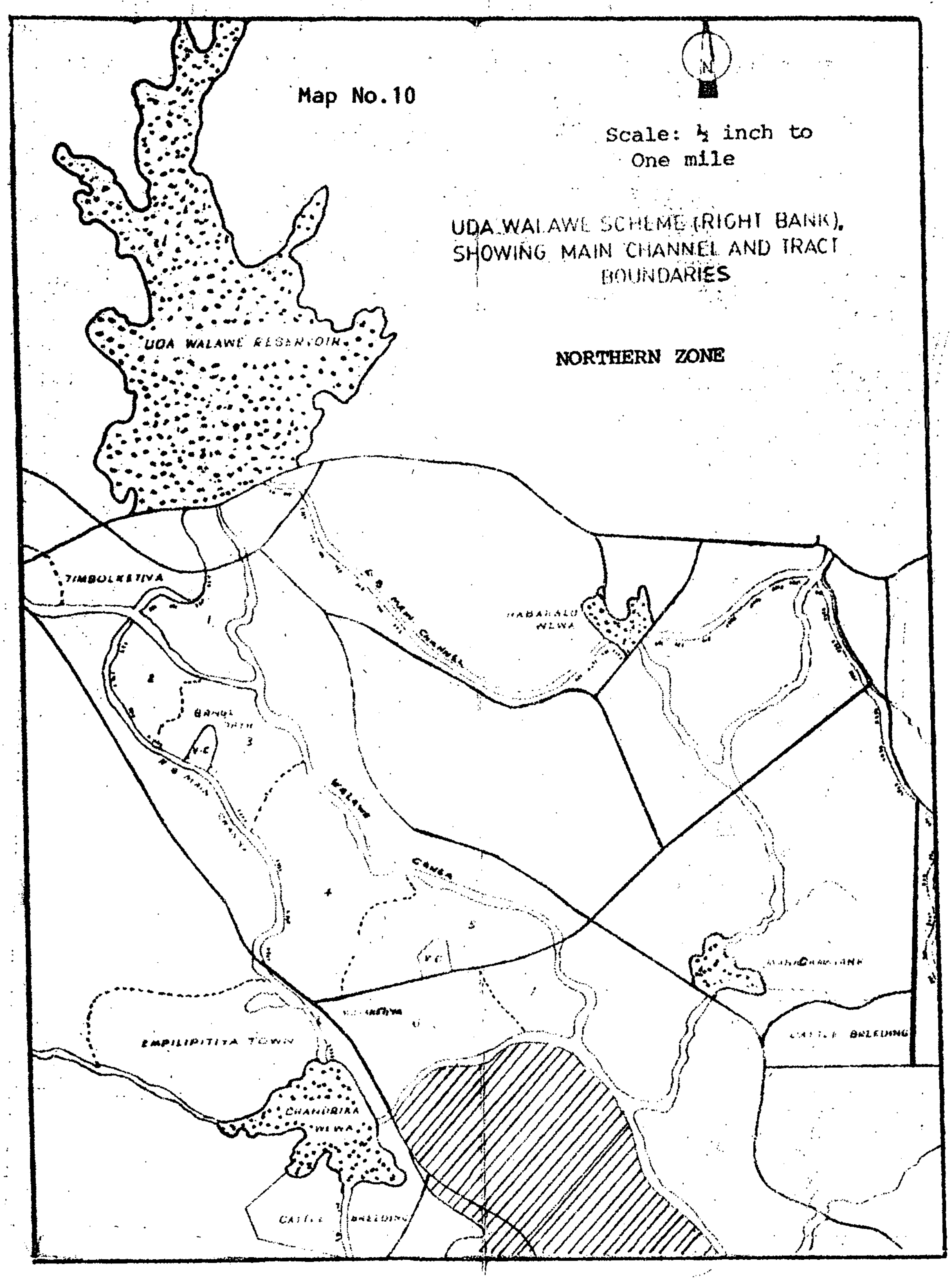


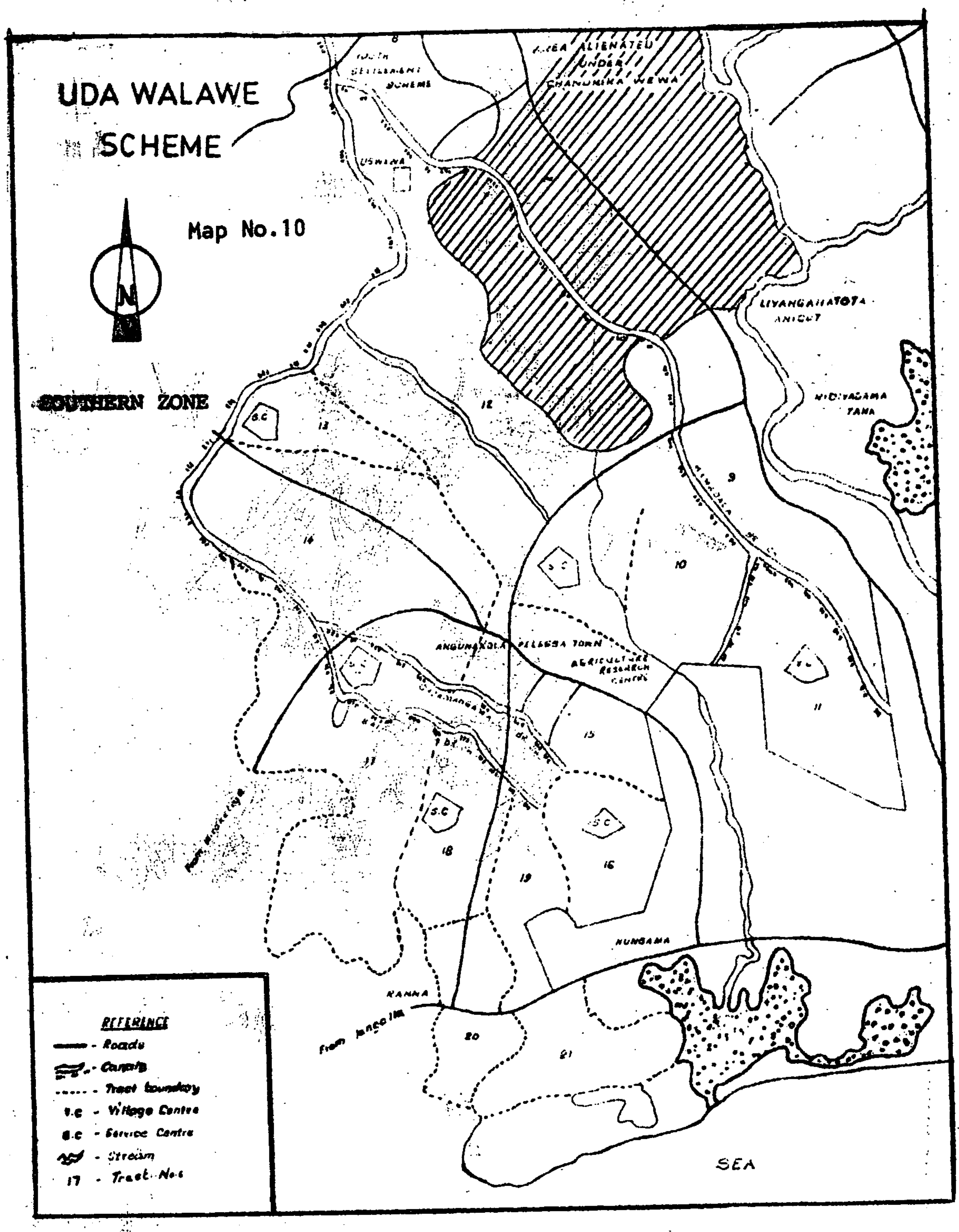
Map No.9

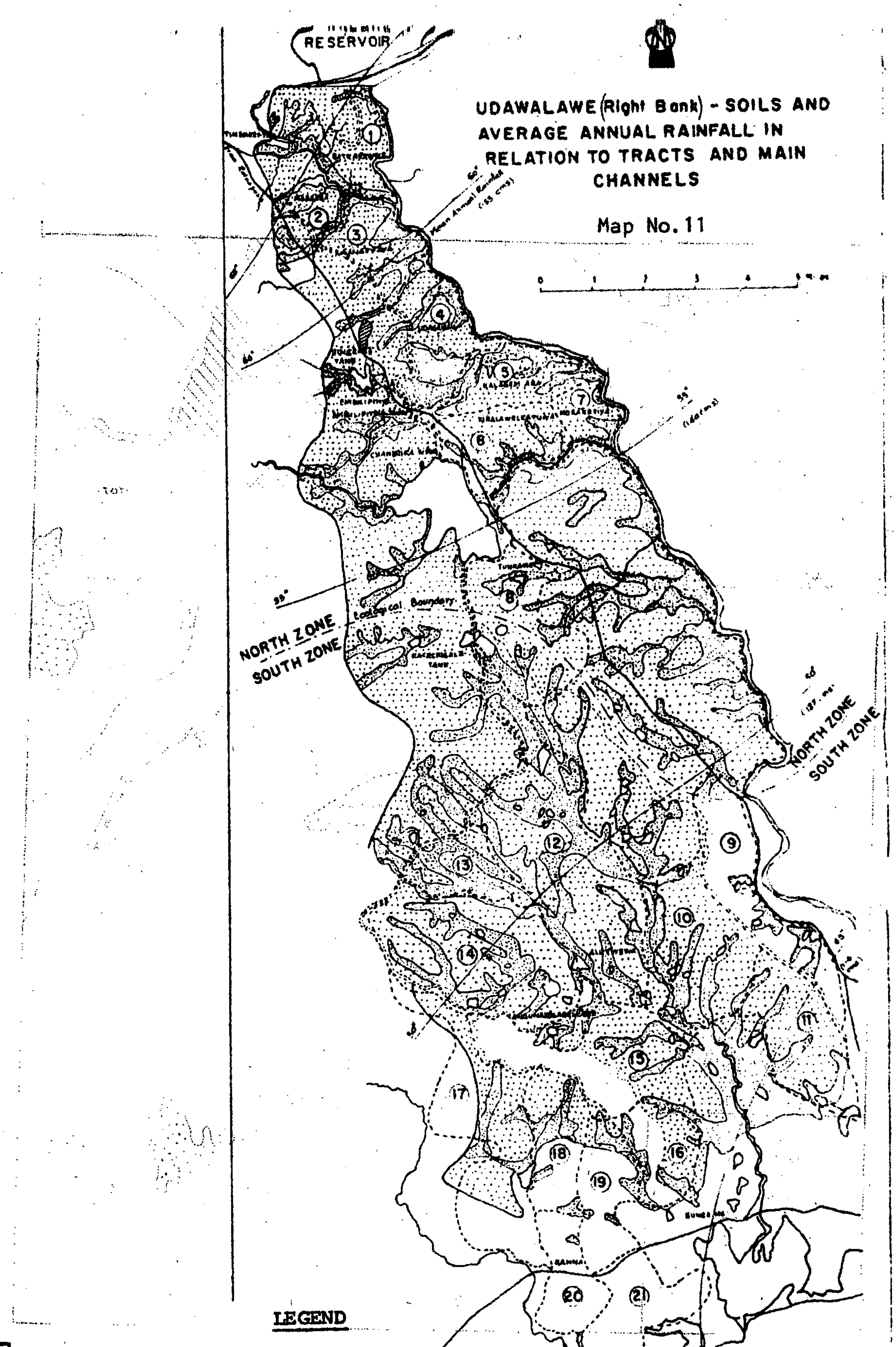
EXISTING BOUNDARIES OF PADDY ALLOTMENTS IN TRACT 8 - STAGE-I KAUDULLA.

Scale of 16 Chains to an Inch




Map No.10
N
Scale: ½ inch to
One mile
UDA WALAWE SCHEME (RIGHT BANK),
SHOWING MAIN CHANNEL AND TRACT
BOUNDARIES
NORTHERN ZONE
UDA WALAWE RESERVOIR
TIMBOLKETIYA
EMPILIPITIYA TOWN
CHANDRIKA
WEWA
CATTLE BREEDING
CATTLE BREEDING


UDA WALAWE
SCHEME
Map No.10
N
SOUTHERN ZONE
USWANA
LIYANGAHATOTA
ANICUT
12
13
14
9
10
11
15
16
18
19
20
21
AGRICULTURE
RESEARCH
CENTRE
NUNGAMA
RANNA
SEA
REFERENCE
- Roads
- Canals
- Tract boundary
- Village Centre
- Service Centre
- Stream
17 - Tract No.s



LEGEND

UPLAND SOILS REDDISH BROWN EARTHS: Dark red or yellowish red sandy clay loams moderately deep to deep, well drained undulating topography, well drained (occasionally gravelly) sub-soils of I5"-36" depth (includes for Uda Walawe undulating rolling Ranna Association).

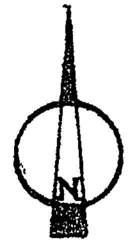
BOTTOM LAND SOILS LOW HUMIC GLEYS: Sandy clay loams, dark brown, yellowish brown or greyish moderately dep to deep, imperfectly to poorly drained (includes Uda Walawe Malabatu and Sirambala Associations).

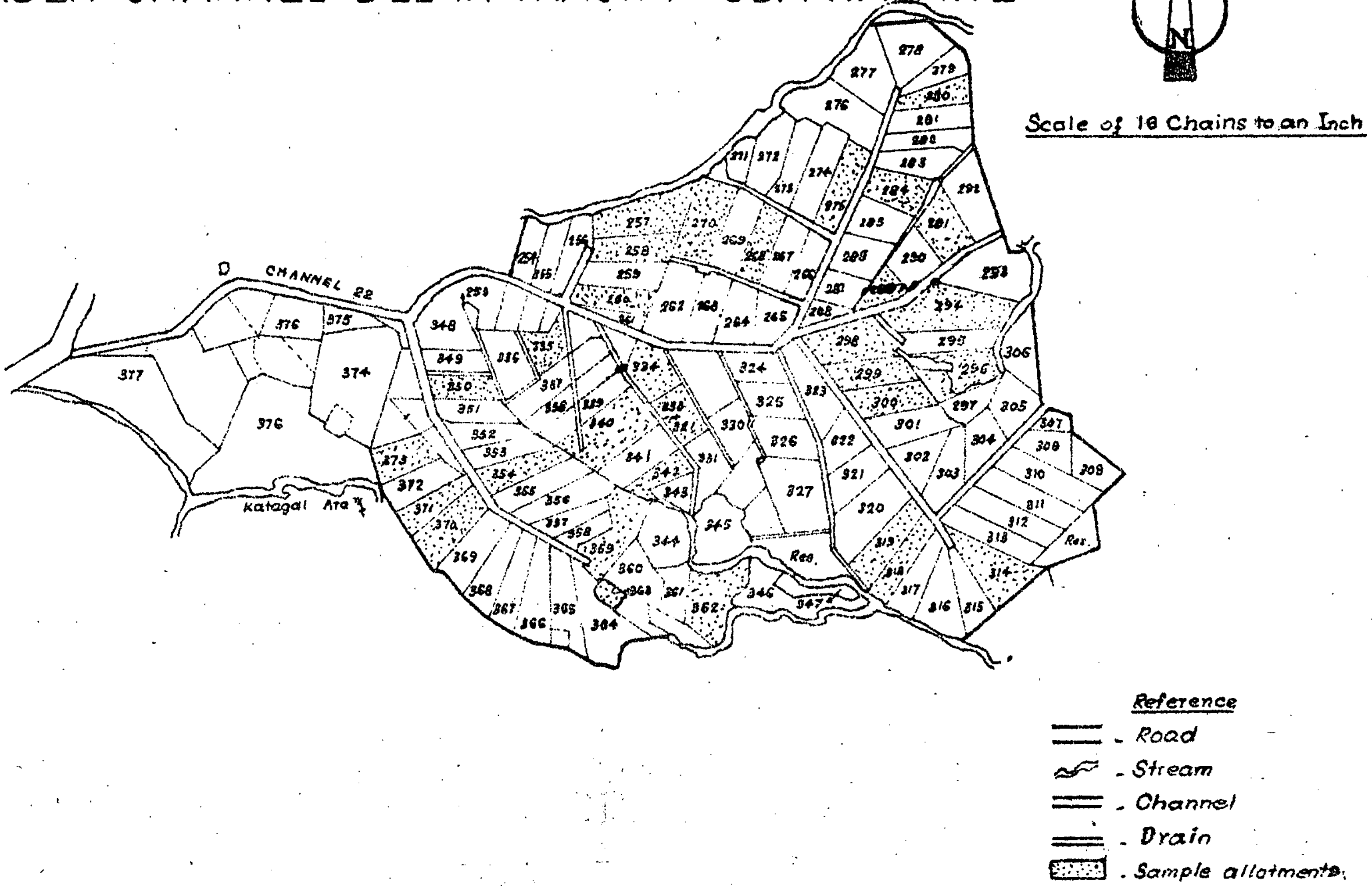
ALLUVIAL SOILS: Deep brown loams to loamy sands deep and moderately well to poorly drained.

MISCELLANEOUS LAND TYPES: Land with irregular relief and rock outcrops.

Map No. 12

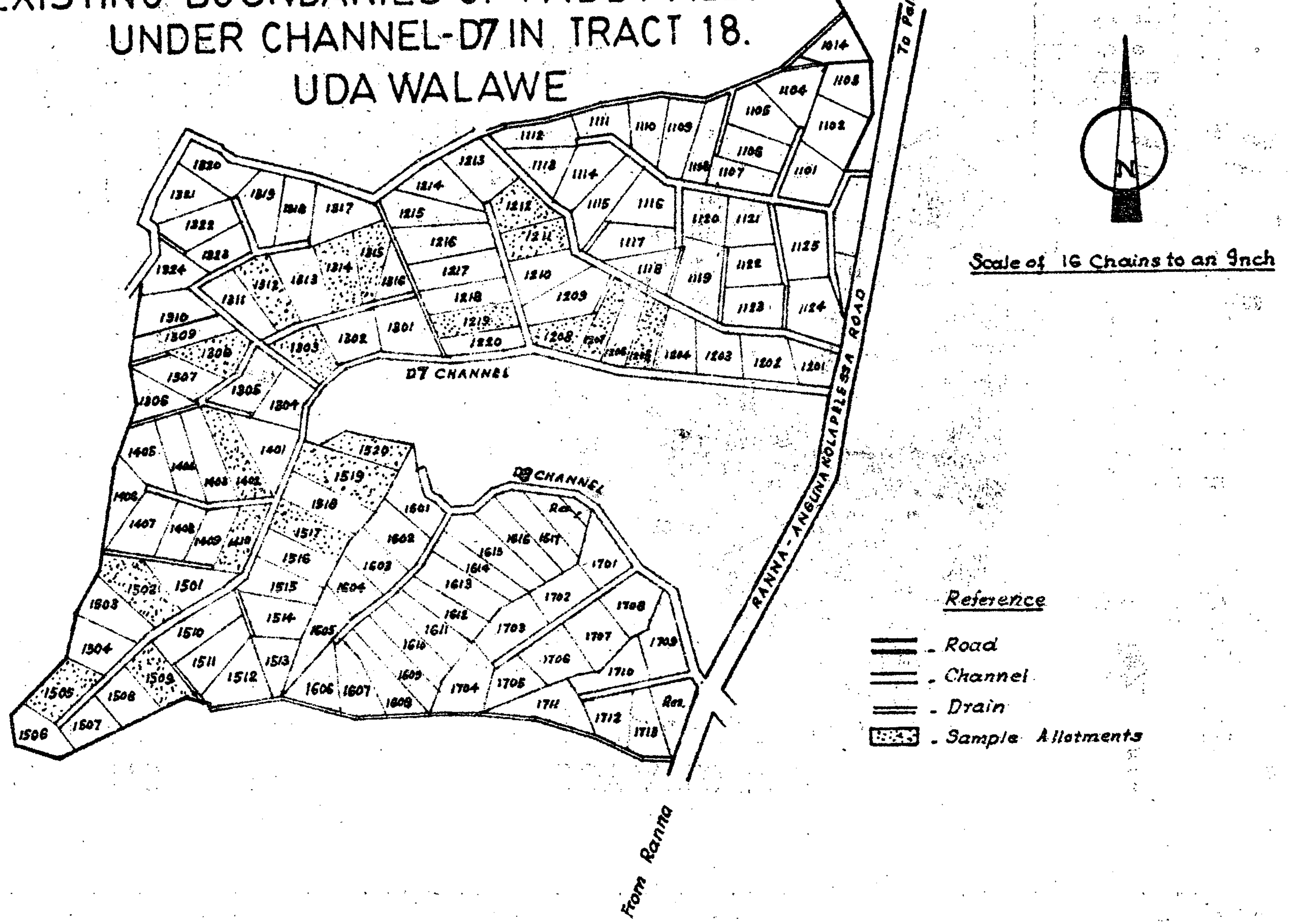
EXISTING BOUNDARIES OF PADDY ALLOTMENTS UNDER CHANNEL - D22 IN TRACT 4 - UDA WALAWE





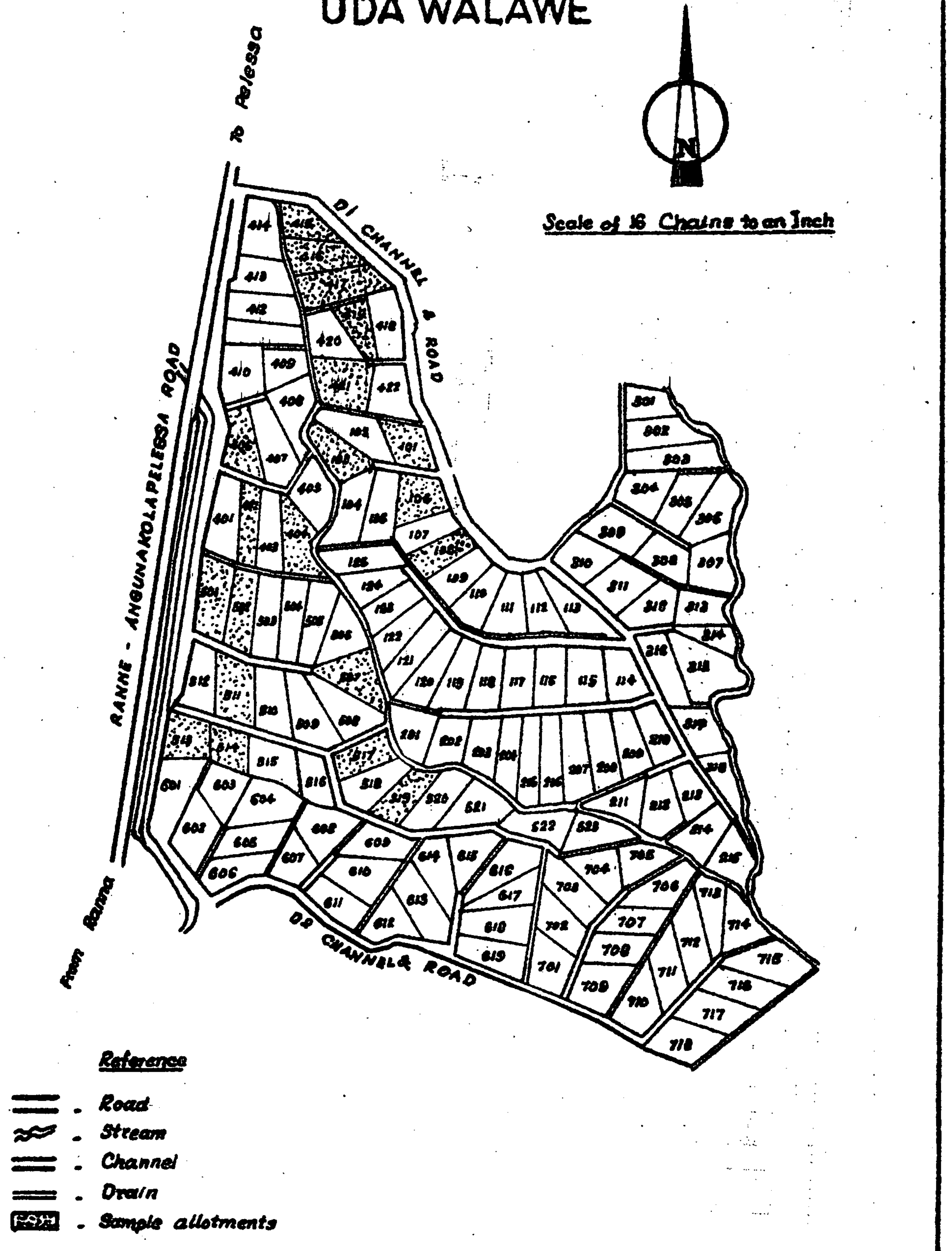
Map No. 13

EXISTING BOUNDARIES OF PADDY ALLOTMENTS UNDER CHANNEL-D7 IN TRACT 18. UDA WALAWE



Map No. 14

EXISTING BOUNDARIES OF PADDY ALLOTMENTS UNDER CHANNEL - D1, D2 - TRACT 19 UDA WALAWE



PHYSICAL FARM INPUTS

Schedule I
Name .... Week No. [ ] Scheme [ ] Farmer No. [ ] Investigators Name ....
Plot No. ....

Inputs / Land Types		Labour Inputs																			Power							Inputs							Other Inputs	
		Crop	Operation	Worker	Hours	Operation	Worker	Hours	Operation	Worker	Hours	Operation	Worker	Hours	Operation	Worker	Hours	Operation	Worker	Hours	Type	Own/hired	Operation Implements	Hrs. x No. of power units	Acre covered	No. of passes	No. of pair of buffaloes used	Type	Own/hired operation	Implements	Hrs. x No. of power units	Acres covered	No. of passes	No. ofpair of buffalo used	Type	Weight
Lowland: Allotted	1																																			
Lowland: Rented in	2																																			
Lowland: Encroached	3																																			
Lowland: Other	4																																			
OFFICE USE	5																																			
Chena	6																																			
Chena	6																																			
Chena	6																																			
Chena	6																																			
Chena	6																																			
Rainfed: Highland	7																																			
Rainfed: Highland	7																																			
Rainfed: Highland	7																																			
Rainfed: Highland	7																																			
Irrigated: Highland	8																																			
Irrigated: Highland	8																																			
Irrigated: Highland	8																																			

Comments, difficulties etc. ....

SCHEDULE I - C O D E S

CROP CODES

00 Paddy - Local
01 Paddy - 3 months
02 Paddy - 3½ months
03 Paddy - 4 months
04 Paddy - 4½ months
11 Kurrakkan
12 Maize
13 Sorghum
14 Meneri
21 Green gram
22 Black gram
23 Cowpea
24 Soya bean
25 Other legumes
31 Red onion
32 Bombay onion
33 Mustard
41 Gingelli
42 Ground nut
51 Tobacco
52 Cotton
61 Chillies
71 Capsicum
72 Other vegetables
81 Manioc
82 Other Root crops

OPERATION CODES

11 Clearing & burning
12 Mammoty tilling
13 Cleaning/plastering bunds
14 Hand levelling
21 Driving tractor - 1st ploughing
22 Driving tractor - 2nd ploughing
23 Driving tractor - levelling
31 Driving buffalo - 1st ploughing
32 Driving buffalo - 2nd ploughing
33 Driving buffalo - mudding/trampling
34 Driving buffalo - levelling
41 Nursery work
42 Broadcast
43 Row transplanting
44 Random transplanting
45 Dibbling (upland crops)
46 Filling gaps
51 Hand weeding
52 Applying Herbicide
53 Applying insecticide/fungicide
54 Applying fertilizer
55 Regulating water
56 Clearing channels/drains
57 Watching
61 Harvesting
70 Cleaning threshing floor
71 Threshing by tractor
72 Threshing by buffalo
73 Threshing by machine
74 Threshing by hand/feet
75 Drying/curing/grading/cleaning
81 Winnowing by 4 w.t.
82 Winnowing by 2 w.t.
83 " hand
84 " machine
85 " human powered machine
91 Bagging for market
92 Transport to Market/house by lorry
93 Transport by 4 w.t.
94 Transport by 2 w.t.
95 Transport by oxcart
96 Transport by bicycle
97 Transport by headload
98 Waiting at market
01 Herding buffaloes
02 Herding cattle
03 Fencing
04 Stall feeding buffalo
05 Stall feeding other livestock

WORKER CODES

11 Family male
12 Family female
13 Family child
21 Exchange male
22 Exchange female
23 Exchange child
31 Hired permanent male
32 Hired permanent female
33 Hired permanent child
41 Hired casual male
42 Hired casual female
43 Hired casual child

POWER CODES

Type
1 4-wheel tractor
2 2-wheel tractor
3 Buffalo
4 Cattle
5 Water Pump
6 Threshing machine
7. Other

Ownership
1 Own
2 Hired
3 Exchange

Operation
1 First Ploughing
2 Second ploughing
3 Levelling
4 Trampling/mudding buffalo
5 Threshing
6 Winnowing
7 Pumping
8 Transport 0 = Other (specify)

Implements
1 Tyne tiller
2 Rotavator
3 Disc plough
4 Mouldboard (for tractors)
5 Levelling board (for tractors)
0 Trailer/cart
6 Country plough (buffalo)
7 Iron plough (buffalo)
8 Levelling board (buffalo)
9 Winnowing fan

OTHER INPUTS

Type
1 Seed
2 Fertilizer
3 Insecticide
4 Fungicide
5 Herbicide

SCHEDULE 2 FINANCIAL TRANSACTIONS

SCHEDULE 2
Farmer's name.......... Period [,] Scheme [ ] Farmer No. [,] Investigator's name ....
Tract No. ....
Plot No. ....

INCOMINGS

Item	I.D.	Worker type	Job type		No. days		Location	Total revenue Rs.Cts
1. Off-farm earnings (labour only)	1			x x x x		x x x		.
	1			x x x x		x x x		.
	1			x x x x		x x x		.
	1			x x x x		x x x		.

Item		Type	Operation	Acres covered	Days x No. power units	Nos. pairs animal	Locn.	Total Rs.cts Revenue
2. Hiring out tractors, machinery, animals etc. for field work or transport	2							.
	2							.
	2							.
	2							.

Item		Type	Purchaser				Locn.	Total revenue Rs.cts
3. Sale of crop or livestock produce	3			x x x x	x x x x x x	x x x		.
	3			x x x x	x x x x x x	x x x		.
	3			x x x x	x x x x x x	x x x		.

Item		Type						Total revenue Rs.cts
4. Income from Pensions/remittances	4		x x	x x x x	x x x x x x	x x x	x	.
	4		x x	x x x x	x x x x x	x x x	x	.
	0		x x	x x x x	x x x x x	x x x	x	x x x x x x x x

Item		Type	Purchaser		Nos.		Locn.	Total revenue Rs.cts
5. a. Sale of tractors, implements equipment, livestock	5			x x x x		x x x		.
	5			x x x x		x x x		.
b. Household/personal items in excess of Rs.20	6			x x x x		x x x		.
	6			x x x x		x x x		.
Total income for period	7	x x	x x	x x x x x	x x x x x x	x x x	x	

OUTGOINGS

Item	I.D.	Worker type	Operation	Nature of pay	Source of funds	No. persons	Total No. days	Value (own funds) Rs.cts	Value (credit funds or credit account) Rs.cts
6. Hiring-in of labour	1						.0	.	.
	1						.0	.	.
	1						.0	.	.
	1						.0	.	.

Item		Type	Operation	Nat. pay	So. funds	W/wout driv.	Dys x No. pow. units / No. acres	Value Rs.cts (own funds)	Value (credit funds or credit accounts) Rs.cts
7. Hiring-in of tractors, buffaloes, sprayers, etc	2						.	.	.
	2						.	.	.
	2						.	.	.
	2						.	.	.

Item		Where bought	Input type	Nat. pay	So. funds		Qty.	Value (own funds) Rs.cts	Value (credit funds or credit account) Rs.cts
8. Purchase of inputs for crops and livestock	3					x x	.0	.	.
	3					x x	.0	.	.
	3					x x	.0	.	.

Item					So. funds			Value Rs.cts	Rs.cts
9. Repayment of credit	4						x x x x x	.	.
	4						x x x x x	.	.

Item		Where repaired	Type		So. funds		Nos.	Value (own funds) Rs.Cts.	Value (Credit funds or credit accounts) Rs.cts
10. Repairs to farm machinery, equipment	5					x x	0	.	.

Item		Source	Type of item	nat. pay	So. funds	New/second hand		Value (own funds) Rs.cts	Value (Credit funds or credit account) Rs.cts.
11. a. Purchase of: tractors, implements, equipment, livestock.	6						.0	.	.
	6						.0	.	.

Item							Nos.	Value (own funds) Rs.cts	Value (credit funds or credit accounts) Rs.cts
b. Household/personal items in excess of Rs.20.	7						.0	.	.
	7						.0	.	.
Total expenditure for prd.	8	x x	x x	x	x x	x x	x x x x x	Total (own funds) Rs.cts.	Total (credit funds or credit account) Rs.cts

SCHEDULE 3 - Start of Season baseline survey

Period No. 0,0 Scheme ☐ Farmer No. ☐ Investigator's name ....

Farmer's name ....

Tract No. .....

Plot No. .....

Status of Land Preparation for Maha '79-80 as at 1/8/79

Details of any crops from Yala '79 still in fields as at 1/8/79

		Acres available for cultivation Maha 79-80	Acres cleared and burned (chena)	Acres on which 1st ploughing is completed	Acres on which 1st and 2nd ploughing completed	Acres on which 1st and 2nd ploughing and levelling are completed	Not yet harvested: Crop	Not yet harvested: Acres	Harvested, but not yet threshed: Crop	Harvested, but not yet threshed: Acres
LOWLAND	Allotted									
LOWLAND	Rented in									
LOWLAND	Encroached									
LOWLAND	Other									
	OFFICE USE									
	Chena									
	Chena									
	Chena									
	Rainfed Highland									
	Rainfed Highland									
	Rainfed Highland									
	Irrigated Highland									
	Irrigated Highland									
	Irrigated Highland									

SCHEDULE 4 DAYS ON WHICH FARMERS OBTAIN WATER

Week No. [ ] Scheme [ ]

Farmer's Name	Sample No.	Days on which water was taken this week							Days on which* allotted paddy had dried out this week	Remarks
		1	2	3	4	5	6	7		

* If applicable

SCHEDULE 5 **ACREAGE MEASUREMENT**

Scheme
Tract No. ....
Plot No. ....

Farmer's Name ....
Sample No.

Investigator ....

Note: (1) As in Schedule 1.

USE OVERFLOW IF NECESSARY

	Land Type (1)	Crop (1)	Rain fed or Irrigated	Planted acreage (farmer's estimate) — Maha 1979 - 1980	Acreage of any un planted area of this land type	% of area transplanted (PADDY ONLY)	No. of liyaddes in the planted area (PADDY ONLY)	MEASUREMENTS: Side	Bearing	Length	Office Use	(Contd.) Side	Bearing	Length	Office Use	Comments on condition of crop etc.
1								A-B	....	....	...	....	....	....	.....	
								B-C	....	....	...	....	....	....	.....	
								C-D	....	....	...	....	....	....	.....	
								D-E	....	....	...	....	....	....	.....	
								E-F	....	....	...	....	....	....	.....	
2								A-B	....	....	...	....	....	....	.....	
								B-C	....	....	...	....	....	....	.....	
								C-D	....	....	...	....	....	....	.....	
								D-E	....	....	...	....	....	....	.....	
								E-F	....	....	...	....	....	....	.....	
3								A-B	....	....	...	....	....	....	.....	
								B-C	....	....	...	....	....	....	.....	
								C-D	....	....	...	....	....	....	.....	
								D-E	....	....	...	....	....	....	.....	
								E-F	....	....	...	....	....	....	.....	

LEAF OVER SKETCH

ACREAGE MEASUREMENT FOR POWER OWNERS - MAHA 1979/80

SCHEDULE 5A

Scheme [ ]   Owners name : ....

Tract ....   Sample No. [ ]

Plot No. ....

Investigator ....

	1	2	3	4	5	6		1	2	3	4	5	6
	Land Type	Tenurial Status	Crop	Estimate of planted	Acreage unplant-ed	% area trans-planted PADDY ONLY		Land Type	Tenurial Status	Crop	Estimate of planted	Acreage unplanted	% area transplant-ed PADDY ONLY
1							4						
2							5						
3							6						

SCHEDULE 6 HARVEST DETAILS

Scheme ....

Investigator ....

Farmer's Owner's Name	Sample No.	Land Type	Crop	Variety	Week of harvest	SPECIFY UNITS				Office use	Remarks
						Yield retained for domestic use	Yield given as land rent	Yield given as payments for agric. operations	Yield sold		

For chillies: Specify whether green or dried
For maize: Specify whether as grain or on cob
For groundnuts: Specify whether with or without shell

Note: give what the farmer has done, or intends to do.

SCHEDULE 7 USE OF ANIMAL MANURE

FARMER SAMPLE AND BUFFALO OWNERS

Scheme ....   Investigator ....

Did you use any animal manure on your crops?

Name	Sample No.	Maha 1979/80				Yala 1980			
		Crop	Quantity+		Price/Unit+	Crop	Quantity+		Price/Unit+
			Own	Bought			Own	Bought	

+ Specify Units

SCHEDULE 8 LAND AND HARVEST DETAILS YALA 1980

Scheme ....

Owner/Farmer

Investigator ....

Name	Sample No.	Land Type[1]	Rainfed or irrigated	Tenure[2]	Crop type and variety	Estimated acreage planted	% transplanted[3]	Week of harvest[4]	Intended Disposal of Harvest[5]: Retain	Sell	Land Rent	Agric. payments	Remarks

(CULTIVATED LAND: Name through Week of harvest; HARVEST DETAILS: Intended Disposal of Harvest)

1. Lowland
   Highland
   Chena

2. Owned/allotted
   Rented/leased/mortgaged in
   Encroached

3. Paddy only

4. For paddy, any harvest after wk.50. For others any harvest after wk.45

5. Specify units

BUFFALO LOG BOOK **RECORD OF WORK DONE** **SCHEDULE A**

Name of owner : .... Village : .... Tract No. .... Investigator : ....

Ownership Status [ ] Scheme [ ] Owner No. [ ] Week No. [ ]

Day of the week																					
Work done for (circle):	Self	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Relative	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Other farmer	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Miles to work from normal base																					
Operation performed (circle):	1st ploughing	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	2nd ploughing	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Levelling	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Threshing	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
	Winnowing	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Transport (agric. goods)	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Transport (non agr. goods)	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	Transport (people)	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
	Other	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
No. of pairs of buffalo used																					
Type of implement used (codes overleaf)																					
No. acres covered in this operation		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Time spent on operation (hours)		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Is payment to be made (circle):	Immediately	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	at the end of season	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Will payment be (circle)	In cash	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	In kind	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
If buffaloes not working on any day give reasons (code overleaf)																					

CODES

Ownership Status

1. Owns 4 wt only
2. Owns 2 wt only
3. Owns 4 wt plus buffalo
4. Owns 2 wt plus buffalo
5. Owns 4 wt plus 2 wt
6. Owns 4 wt plus 2 wt plus Buffalo
7. Owns buffalo only

Type of Implement

1. Tyne tiller
2. Rotavator
3. Disc plough
4. Mouldboard plough (tractors)
5. Levelling board (tractors)
6. Country plough (buffalo)
7. Iron plough (buffalo)
8. Levelling board (buffalo)
9. Winnowing fan
0. Trailer or cart

Reasons for Non-use

1. Tractor temporarily broken down
2. Tractor broken beyond repair
3. Buffalo sick/ injured/ pregnant/ lactating/ resting
4. Implement broken
5. Owner not looking for work
6. Driver sick or absent
7. Fuel not available
8. No work available
9. Bad weather
0. Other (specify)

TRACTOR LOG BOOK

RECORD OF WORK DONE

SCHEDULE A1

Name of Owner .... Village .... Tract No. .... Investigator ....

Ownership Status [ ] Scheme [ ] Owner No. [ ] Tractor No. [|] Week No. [ ]

Day of the Week:																					
Work done for: (circle)	Self	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Relative	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Others	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Miles to work from normal base																					
Operation performed (circle)	Ist ploughing	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	2nd ploughing	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Levelling	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Threshing	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
	Winnowing	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Transport (Agric. goods)	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Transport (Non-agric goods)	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	Transport (People)	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
	Other	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Type of implement used (code overleaf)																					
No. of acres covered in opn.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Time spent on operation (hours)		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Payment to be made (circle):	Immediately	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	End of season	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	In cash	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	In kind	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Reasons for non-use (code over)																					

CODES

Ownership Status

1. Owns 4 wt only
2. Owns 2 wt only
3. Owns 4 wt plus buffalo
4. Owns 2 wt plus buffalo
5. Owns 4 wt plus 2 wt
6. Owns 4 wt plus 2 wt plus buffalo
7. Owns buffalo only

Type of Implement

1. Tyne tiller
2. Rotavator
3. Disc plough
4. Mouldboard plough (tractors)
5. Levelling board (tractors)
6. Country plough (buffalo)
7. Iron plough (buffalo)
8. Levelling board (buffalo)
9. Winnowing fan
0. Trailer or cart

Reason for Non-use

1. Tractor temporarily broken down
2. Tractor broken beyond repair
3. Buffalo sick/ injured/ pregnant/ Lactating/ resting
4. Implement broken
5. Owner not looking for work
6. Driver sick or absent
7. Fuel not available
8. No work available
9. Bad weather
0. Other (specify)

SCHEDULE A [illegible]: BUFFALOES - RECORD OF PURCHASES & SALES OF RELATED ITEMS

Month No. [ ] Scheme [ ] Owner No. [ ] Ownership status [ ] On/off scheme [ ]

Owner's name .... Investigator's name ....

Location ....

Tract (if any) ....

Purchase/hire			Sales		Purchase/hire			Sales		Purchase/hire			Sales		Purchase/hire			Sales	
Item type	Cost Rs.cts	(If applicable) Total No. labour dys hired	Item type	Value Rs.cts	Item type	Cost Rs.cts	(If applicable) Total No. labour dys hired	Item type	Value Rs.cts	Item type	Cost Rs.cts	(If applicable) Total No. labour dys hired	Item type	Value Rs.cts	Item type	Cost Rs.cts	(If applicable) Total No. labour dys hired	Item type	Value Rs.cts

CODES

Ownership Status

1 Owns buffalo only
2 Owns buffalo plus 4 w.t.
3 Owns buffalo plus 2 w.t.
4 Owns buffalo plus 4 w.t. plus 2 w.t.

Purchase/hire item types

0 Feed
1 Medicine
2 Repairs to equipment
3 Permanent adult drivers/operators
4 Permanent adult for herding
5 Permanent child for herding
6 Casual adult driver/operator
7 Casual child driver/operator
8 Casual adult for herding
9 Casual child for herding

Sales item types

1 Milk
2 Curd
3 Manure
4 Other (specify below)

....
....
....

On/off scheme

1 Resides on scheme
2 Resides off scheme

Comments, difficulties, etc. ....
....
....

SCHEDULE A IO TRACTORS AND IMPLEMENTS - RECORD OF MAINTENANCE, FUEL AND REPAIRS

Scheme Owner No. Ownership Status On/Off Scheme

Owner's Name .... Investigator's Name ....

Location ....

Tract (if any) .... Tractor Reg. No.

Week No.	Fuel Type	Fuel Costs Rs. cts.	Service & Repairs Type	Service & Repairs Costs Rs. cts.	Week No.	Fuel Type	Fuel Costs Rs. cts.	Service & Repairs Type	Service & Repairs Costs Rs. cts.	Week No.	Fuel Type	Fuel Costs Rs. cts.	Service & Repairs Type	Service & Repairs Costs Rs. cts.

Note: Under service and repair costs include both materials and labour charges. Also include oil, grease, etc., between service intervals.

Ownership Status

I. Owns 4 wt only
2. Owns 2 wt only
3. Owns 4 wt + buffalo
4. Owns 2 wt + buffalo
5. Owns 4 wt + 2 wt
6. Owns 4 wt + 2 wt + buffalo

On/Off Scheme

I. Resides on scheme
2. Resides off scheme

Fuel Type

I. Diesel
2. Kerosene
3. Petrol

Tractor Service & Repairs

II Service
Repair/replacement of:
I2 tyres and tubes
I3 wheel bearings
I4 transmission (clutch, gearbox, differential)
I5 electrical equipment, starter motor, dynamo, fan belt, battery, lights
I6 engine
I7 Other repairs (specify)

Implements service& Repairs

Repair/replacement of:
2I tyne tiller
22 rotavator
23 disc plough
24 other plough
25 tractor driven: pump
26 " " Thresher
27 " " winnower
28 " " trailer
29 Other Service/Repair (Specify)

Comments, difficulties, etc. ....

....

....

SCHEDULE B Buffalo Owners: Opening Stock as at 1/8/79

Scheme [ ] Owner No. [ ] Ownerhsip status [ ] On/off scheme [ ]

Owner's name .... Investigator's name

Location ....

Tract (if any) ....

← BUFFALOES →												← EQUIPMENT →																			
Type	Nos.	Type	Nos.	Type	Nos.	Type	Nos.	Type	Nos.	Type	Nos.	Type	Nos.	Type	Nos.	Type	Nos.	Type	Nos.	Type	Nos.	Type	Nos.	Type	Nos.	Type	Nos.	Type	Nos.	Type	Nos.

CODES

Ownership status

1 Owns buffalo only
2 Owns buffalo plus 4 w.t.
3 Owns buffalo plus 2 w.t.
4 Owns buffalo plus 4 w.t. plus 2 w.t.

On/off scheme

1 Resides on scheme
2 Resides off scheme

Buffalo type

1 Males 2 years and over
2 Females 2 years and over
3 Males up to 2 years
4 Females up to 2 years
5 Senile/sick/injured adult buffalo

Equipment type

1 Country plough
2 Iron plough
3 Levelling board
4 Cart
5 Other (specify below)
....
....

Comments, difficulties, etc. ....
....

SCHEDULE B1 Tractor Owners: Opening Stock as at 1/8/79

Scheme [ ] Owner No. [ ] Ownership status [ ] On/Off scheme [ ]

Owner's name .... Investigator's name...........

Location ....

Tract (if any) ....

← TRACTORS → | ← EQUIPMENT →

Tractor type	Fuel type	Condition	Nos.	Tractor type	Fuel type	Condition	Nos.	Tractor type	Fuel type	Condition	Nos.	Tractor type	Fuel type	Condition	Nos.	Tractor type	Fuel type	Condition	Nos.	Tractor type	Fuel type	Condition	Nos.	Type	Condition	Nos.	Type	Condition	Nos.	Type	Condition	Nos.	Type	Condition	Nos.	Type	Condition	Nos.	Type	Condition	Nos.	Type	Condition	Nos.	Type	Condition	Nos.	Type	Condition	Nos.	Type	Condition	Nos.

CODES

Ownership status

1 Owns 4 w.t. only
2 Owns 2 w.t. only
3 Owns 4 w.t. plus buffalo
4 Owns 2 w.t. plus buffalo
5 Owns 4 w.t. plus 2 w.t.
6 Owns 4 w.t. plus 2 w.t. plus buffalo

On/Off Scheme

1 Resides on scheme
2 Resides off scheme

Tractor type

1 4 w.t. under 2 years
2 4 w.t. 2 - 5 years
3 4 w.t. 6 yrs & over
4 2 w.t. under 2 years
5 2 w.t. 2 - 5 years
6 2 w.t. 6 yrs & over

Tractor Fuel type

1 Diesel
2 Kerosene
3 Petrol

Tractor condition

1 Working
2 Broken

Equipment type

1 Mudwheels
2 Tine tiller
3 Rotavator
4 Mouldboard plough
5 Disc plough
6 Levelling board
7 Winnowing fan
8 Pump
9 Trailer
0 Other (specify below)

Equipment condition

1 Working
2 Broken

Comments, difficulties, etc. ....
....

SCHEDULE C. BUFFALO HERD CHANGES

Month No. ☐ Scheme ☐ Owner No. ☐ Ownership status ☐ On or off scheme ☐

Owner's name ....

Location ....

Tract (if any) ....

Investigator's name ....

Type	In/out	Method	Nos.	Value Rs.cts	Type	In/out	Method	Nos.	Value Rs.cts	Type	In/out	Method	Nos.	Value Rs.cts	Type	In/out	Method	Nos.	Value Rs.cts

CODES

Ownership Status

1 Owns buffaloes only
2 Owns buffaloes plus 4-wheel tractor
3 Owns buffaloes plus 2-wheel tractor
4 Owns buffaloes plus 2-wheel tractor plus 4-wheel tractor

On-Off Scheme

1 Resides on scheme
2 Resides off scheme

Type

1 Male over 2 years
2 Female over 2 years
3 Male under 2 years
4 Female under 2 years
5 Senile/sick/injured male or female

In/Out

1 Incoming to stock
2 Outgoing from stock

Method

1 Birth
2 Purchase
3 Received as gift
6 Died
7 Sold as working animal
8 Sold for slaughter
9 Given away
0 Stolen

Comments, difficulties, etc. ....

....

SCHEDULE D MONTHLY RECORD OF FARMING ACTIVITIES

Schedule D Month No. [ ] Scheme [ ] Owner No. [ ] Investigators Name ....

Owner's Name ....

Plot No. ....

Inputs / Land Types		Labour Inputs																						Power								Inputs								Other Inputs	
		Crop	Operation	Worker	Days	Operation	Worker	Days	Operation	Worker	Days	Operation	Worker	Days	Operation	Worker	Days	Operation	Worker	Days	Operation	Worker	Days	Type	Own/hired	Operation	Implements	Hrs x No. of power units	Acre covered	No. of passes	No. of pair of buffaloes used	Type	Own/hired	operation	Implements	Hrs x No. of power units	Acres covered	No. of passes	No. of pair of buffaloes used	Type	Weight
Lowland: Allotted *	1																																								
Lowland: Rented in	2																																								
Lowland: Encroached	3																																								
Lowland: Other	4																																								
OFFICE USE	5																																								
Chena	6																																								
Chena	6																																								
Chena	6																																								
Chena	6																																								
Chena	6																																								
Rainfed: Highland	7																																								
Rainfed: Highland	7																																								
Rainfed: Highland	7																																								
Rainfed: Highland	7																																								
Irrigated: Highland	8																																								
Irrigated: Highland	8																																								
Irrigated: Highland	8																																								

Comments, difficulties etc. ....

* or owned

SCHEDULE E MONTHLY RECORD OF FINANCIAL ACTIVITIES

SCHEDULE E

Owner's name.......... Period [ ] Scheme [ ] Owner No. [ ] Investigator's name ....

Tract No. ....

Plot No. ....

INCOMINGS

1. Off-farm earnings (net)	I.D. (1) / Worker type / Job type / x x x x / No. days / x x x / Location / Total revenue Rs.Cts
2. Hiring out tractors, machinery, animals etc. for field work or transport	(2) / Type / Operation / Acres covered / Days x No. power units / Nos. pairs animals / Locn. / Total Rs.cts Revenue
3. Sale of crop or livestock produce	(3) / Type / Purchaser / x x x x / x x x x x / x x x / Locn. / Total revenue Rs.cts
4. Income from Pensions/remittances	(4) / Type / x x / x x x x / x x x x x / x x x / x / Total revenue Rs.cts
	(0) / x x / x x x x / x x x x x / x x x / x / xxxxxxxx
5. a. Sale of tractors, implements equipment, livestock	(5) / Type / Purchaser / x x x x / Nos. / x x x / Locn. / Total revenue Rs.cts
b. Household/personal items in excess of Rs.20	(6) / x x x x / x x x / Total revenue Rs.cts
Total income for period	(7) / x x / x x / x x x x x / x x x x x / x x x / x /

OUTGOINGS

6. Hiring-in of labour (incl. drivers)	I.D. (1) / Worker type / Operation / Nature of pay / Source of funds / No. persons / Total No. days .0 / Value (own funds) Rs.cts / Value (credit funds or credit account) Rs.cts
7. Hiring-in of tractors, buffaloes, sprayers, etc.	(2) / Type / Operation / Nat. pay / So. funds / W/wout driver / Dys x No. pow. units / No. acres / Value Rs.cts (own funds) / Value (credit funds or credit accounts) Rs.cts
8. Purchase of inputs for crops and livestock	(3) / Where bought / Input type / nat. pay. / So. funds / x x / Qty. .0 / Value (own funds) Rs.cts / Value (credit funds or credit account) Rs.cts
9. Repayment of credit	(4) / So. funds / x x x x / Value Rs.cts / Rs.cts
10. Repairs to farm machinery, equipment	(5) / Where repaired / Type / So. funds / x x / Nos. / Value (own funds) Rs.cts / Value (Credit funds or credit accounts) Rs.cts
11. a. Purchase of tractors, implements, equipment, livestock.	(6) / Source / Type of item / nat. pay / So. funds / New/2nd hand / .0 / Value (own funds) Rs.cts / Value (Credit funds or credit account) Rs.cts
b. Household/personal items in excess of Rs.20.	(7) / Nos. .0 / Value (own funds) Rs.cts / Value (credit funds or credit accounts) Rs.cts
Total expenditure for prod.	(8) / x x / x x / x / x x / x x / x x x x / Total (own funds) Rs.cts / Total (credit funds or credit account) Rs.cts

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Scheme ....

Investigator ......

SCHEDULE F   EMPLOYMENT OF DRIVERS BY 2 wt AND 4 wt OWNERS

Owner's Name	Sample No.	Drivers employed in:+ 1979					1980									Average Monthly Salary: Peak Months			Off-peak Months	
		Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	No. of Months	Cash	Kind	Cash	Kind

+ Enter I, ¼, ½, I/4 or O, as appropriate

CHANGES IN LAND TENURE OF FARMERS AND OWNERS

Scheme ....   Investigator ....

Name	Sample No.	Year of Arrival		Land which is:	ACRES IN YEAR OF ARRIVAL			ACRES IN YEAR OF MOST* IMPORTANT POWER PURCHASE AFTER ARRIVAL (4wt, 2wt, buff., bullock)				ACRES IN CURRENT YEAR (1979-80)		
					Low-land	High-land	Chena	(give year)	Low-land	High-land	Chena	Low-land	High-land	Chena
			MAHA	1. Owned/allotted & cultivated by self										
				2. Encroached										
				3. Rented/hired/mortgaged in +										
				4. Owned/allotted but rented etc. out +										
				5. Owned but not cultivated (give reason)										
			YALA	1. Owned/allotted & cultivated by self										
				2. Encroached										
				3. Rented/hired/mortgaged in +										
				4. Owned/allotted but rented etc. out +										
				5. Owned but not cultivated (give reason)										
			MAHA	1. Owned/allotted & cultivated by self										
				2. Encroached										
				3. Rented/hired/mortgaged in +										
				4. Owned/allotted but rented etc out +										
				5. Owned but not cultivated (give reason)										
			YALA	1. Owned/allotted & cultivated by self										
				2. Encroached										
				3. Rented/hired/mortgaged in +										
				4. Owned/allotted but rented etc out +										
				5. Owned but not cultivated (give reason)										

+ Include all sharecropping arrangements (ande, etc.)

* This section for Owners only.

SUPPLEMENTARY QUESTIONS TO FARMERS ON SOURCE OF WATER SUPPLY

(1) For your lowland paddy highland, give a percentage breakdown of where your irrigation water normally comes from for various operations.

% of water normally coming from:

		Field Irrigation Channels	Direct run -off from other farmer's fields	Other sources (Specify e.g. Drains)
MAHA	Land Preparation			
	Planting			
	Crop Development			
YALA	Land Preparation			
	Planting			
	Crop Development			

(2) If water is very abundant in Maha show in the following table any changes in the percentage for your Maha water supply.

% of water coming from:

	Field Irrigation Channels	Direct run-off from other farmer's fields	Other sources (Specify)
Land Preparation			
Planting			
Crop Development			

(3) If water is very scarce in Yala show in the following table any changes in the percentages for your Yala water supply

% of water coming from:

	Field Irrigation Channels	Direct run-off from other farmer's fields	Other sources
Land Preparation			
Planting			
Crop Development			

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