ANIMAL DRAUGHT –

THE ECONOMICS OF REVIVAL

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FOREWORD

This paper represents another in the series of publications arising out of the ARTI/Reading University Study on Farm Power and Water Use in the Dry Zone. The principal objective of this study is to analyse the technical, economic and social implications of the use of alternative farm power technologies and their inter-relationship with water use in the small farm sector.

The authors, who comprise the core of the study team, are Michael Ryan, a Visiting Researcher from the University of Reading, Fredrick Abeyratne, Research and Training Officer, and John Farrington, and ODA/Colombo Plan Adviser. They were initially given the opportunity to present some of their preliminary research findings on animal draught at a Workshop on Buffalo Research in Sri Lanka sponsored by the Swedish Agency for Research Cooperation with Developing countries (SAREC) in November, 1980 at Peradeniya University. The decision was subsequently taken to expand and develop the material presented at the Workshop as an Occasional Publication, permitting the authors to broaden their contribution to the debate currently taking place in Sri Lanka on the most appropriate farm mechanisation strategy for small scale farmers.

Against a background of rapidly rising tractor and fuel costs the arguments for reverting to traditional animal power for cultivation are becoming increasingly convincing. A range of issues relating to the revival of animal use in agriculture are examined: custom rates and organisational difficulties in the power hire market, a broadening of the ownership base of buffaloes and bullocks amongst farm households, and alterations to existing animal husbandry practices and feed regimes that such policies will require.

Recommendations on ways of expanding the national buffalo population and its tillage capability to cope with future farm power requirements are made by the authors over both the long and short term. It is hoped that the arguments put foreward in this publication will ultimately yield net positive value to the nation and to the farmer.

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The authors alone are responsible for any errors that may remain in the text.

Authors.

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1. SUMMARY

The traditional role of draught buffaloes in paddy cultivation has been eroded by tractor power in the last thirty years. Only about one third of the asweddumised acreage in Sri Lanka is currently ploughed by animals, although animal draught continues to play an important role in secondary tillage and levelling, even where mechanised power is most widely represented. With major land development programmes, the demand for draught power is increasing at a time when adverse terms of trade and balance of payments deficits make it difficult to support the present tractor-based strategy. It is against this background that the role of buffaloes in small scale farming is receiving renewed interest. This paper draws on data collected by the current ARTI/ Reading University Study on Farm Power and Water Use in the Dry Zone. Farm management data were collected from a total sample of 443 farmers and power owners (including 88 buffalo owners) at three major colonisation schemes by twice-weekly visits over a 14-month period (August 1979 to October 1980). Preliminary analysis of part of the data has been completed and is examined in this paper.

A comparison of tractor and buffalo operating costs provides strong economic justification for expanding the role of animal power in cultivation. However, imperfections in the farm power hire market prevent such real discrepancies in operating costs from being translated into hire-charge differences at the farm gate which, in turn, leaves the demand for tractor custom services high.

The thrust of our paper is that this imbalance cannot be rectified by intervention in the farm power hire market. What is necessary is a concerted effort to broaden the base of ownership of power, especially that of draught animals.

We discuss a range of issues relevant to a policy of ownership, starting from the poor quality of current statistical information on the national herd, and progressing through our survey data on the patterns of distribution and use of animal draught at three major irrigation schemes, leading finally to a consideration of the options in animal husbandry systems, with an overview of the profitability of each system.

We suggest that,whilst the role of buffaloes could be expanded even in the short to medium term by wider use of ploughs instead of trampling, and by transfer of adult and juvenile animals from areas of low(e.g. Hambantota) to areas of high use-intensity, policy for the long term must concentrate on widespread individual ownership of a pair of animals for draught and milk production. We regard currently widespread open-grazing systems as moribund. For the future, tethering and stall-feeding, possibly using improved feedstuffs, will have to be introduced.

2. INTRODUCTION

The earliest records of the use of domestic buffaloes and cattle in paddy cultivation in Sri Lanka date as far back as the fourth century B.C. By the thirteenth century A.D., livestock rearing and the ploughing of fields by buffalo trampling and animal-drawn implements were well recorded (Siriweera, 1981). Only since the advent of imported tractors in the post-war period, and the introduction of new seed varieties and chemical inputs in more recent years, have significant reductions in the contribution of animal draught occurred.

During this period tractor registrations have increased steadily. In 1960 some 3500 4-wheel tractors had been registered. By 1970 the figure exceeded 10000, and at present stands at over 20000, with a large number of these having appeared since 1977. Similarly, over 12000 2-wheel tractors have been imported into the country since 1970. Along with the rising volume of tractor usage has been a corresponding growth in the proportion of land cultivated annually by mechanical means. Current estimates suggest that about 45% of paddy land in Sri Lanka is cultivated by tractor, with the remainder falling to buffaloes and mammoty tillage (see Table 3). With major land development programmes such as the Mahaweli, the demands for draught power are increasing at a time when adverse terms of trade and deficits in the balance of trade make it difficult to support a tractor strategy on the scale hitherto pursued. The role of buffalo in small scale farming is thus receiving renewed interest.

This paper will not dwell on the historical reasons which resulted in Sri Lanka possessing one of the most mechanised rural sectors in the developing world, a curious position given the island's low average GNP per capita (Rs. 4194, or US $ 254, in 1980, Central Bank Report) and its distribution (Gini coefficient = 0.49) which places access to costly farm machinery beyond the reach of the majority of small scale farmers. Similarly, typical land holding units averaging 2-3 acres per household, sub-divided into small bunded plots for flooding ('liyaddes', often as many as 20-40 per acre), are unsuitable for efficient mechanical tillage, particularly by 4-wheel tractors, whose

normal tillage capacity in any Maha season can vary from 60 to 100 acres depending on the level of utilisation. Finally, labour-displacing mechanised technologies potentially impose a social burden on a country whose most abundant resource is labour: roughly 80% of the national population of 14.9 millions are located in the rural areas.

The explanations for the choice of this particular mechanisation strategy have been well documented elsewhere(for instance, see Burch, 1979). Their origins lie largely in incorrectly perceived notions of shortages in farm power which were thought to be rectifiable only by injections of imported tractors. Since the fifties policy makers have been easily persuaded by these arguments, and continue to be so today.[1] However, cost considerations form the main reason for a fresh reassessment of the role and usefulness of the national animal draught stock. This is evident from the data presented in Table 1.

Table 1. Financial and Economic Estimates of Land Preparation and Threshing Costs by Alternative Methods.

	Land preparation[1]		Threshing	
	Financial Rs/acre	Economic Rs/acre	Financial Rs/acre	Economic Rs/acre
Buffalo pair[2] a)	98.90	91.37		
			118.68	109.64
b)	237.36	219.28		
2-wheel tractor	297.76	283.12	-	-
4-wheel tractor	485.68	457.44	202.32	191.04

Note: See Appendix for explanation of calculations. Economic costs reflect shadow prices.

1. 2-3 operations
2. (a) at $3\frac{1}{3}$ days per acre; (b) at 8 days per acre.

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[1] For a more detailed critique of farm power planning methodology see Farrington et al, 1980c.

From Table 1, the current economic cost to the nation of ploughing an acre of land by buffalo is 32% and 20% of the cost of the same operation performed by 2 and 4-wheel tractors respectively, assuming a buffalo work rate of $3\frac{1}{3}$ days per acre, and 77% and 48% respectively assuming a lower work rate of 8 days per acre (see Atttachment 5 in Appendix). The economic cost of threshing an acre of paddy by tractor is 1.7 times the buffalo cost. With continued increases in world market fuel prices and the capital cost of imported tractors and implements, the cost disparities between animal and mechanical draught can be expected to widen.[1]

However, these wide disparities in national economic costs are not reflected in hire charges to the farmer. The private hire market for draught power is particularly important in Sri Lanka, nearly all of our Dry Zone samples having hired in power for at least one operation in the cultivation calendar. Escalating tractor hire charges passed onto farmers as a result of increasing fuel and other costs permit buffalo owners to reap economic rent on the hire market since their costs have not risen to the same degree. The result is that the opportunities to earn comparatively substantial profit margins per acre for field work are enjoyed largely by owners of buffalo and 2-wheel tractors, i.e. those facing lower operating costs.

This is evident from Table 2, in which profit margins for custom work under high and low cost assumptions are estimated. The ranking of profitability in terms of Rupees per acre places the 2-wheel tractor marginally ahead of buffaloes under either cost assumption, and both power types are substantially in excess of the estimated profit margin for 4-wheel tractors under both cost assumptions, although under the high cost assumption there is very little difference between the profitability of buffalo and 2-wheel tractor operations.

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[1] We have calculated that at real economic costs the total fuel component of annual tractorised land preparation and threshing is approximately 5% of the annual fossil fuel import bill (Farrington et al 1980a).

Since farmers seeking to hire draught power for land preparation enjoy little economic advantage in using buffaloes, greater preference is attached to the ease and convenience of mechanised tillage. Thus, the prevailing tendency for buffalo hire charge to follow tractor rates

Table 2. Estimated Profit Margins for Custom Work.

(Rs/acre for 2-3 tillage operations)

	Hire Charge	Operating Costs		Profit Margin			
		Low	High	Low	%	High	%
Buffalo pair	360[1]	98.90[2]	237.36[2]	261.10	264	122.64	52
2-wheel tractor	450	187.20[3]	297.76[4]	262.80	140	152.24	51
4-wheel tractor	450	298.24[3]	485.68[4]	151.76	51	-35.68	-7

Notes:

1. Based on buffalo pair rental of Rs. 25/day and 8 days/acre for complete land preparation, plus 8 man-days labour at Rs. 20 per man-day.
2. Financial costs, Table 1. Low and high operating costs are determined by the different work rate assumptions used.
3. Based on lower operating costs of 5-year old tractor.
4. Financial costs, Table 1.

encourages the greater use of tractors and results in the loss to the national economy of the potentially superior cost advantages of animal powered tillage.[1]

If policy measures could be taken to translate these cost advantages at the national level into a suitable set of hire charges to the farmer which correctly reflect actual costs of operations, buffalo power would then be placed on a more competitive basis. Such intervention in the hire market is likely to be administratively impossible, and we suggest that a strategy for wider use of animal draught which is to the economic

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[1] Evidence from the Farm Power Study indicates that preferences for particular power types for field work have changed little amongst sample farmers over the last three seasons, despite dramatic increases in diesel prices and capital costs of new imported tractors and implements.

advantage of both the individual farmer and the national economy must be sought elsewhere. In this context, the individual ownership of a pair of draught animals appears to offer the best potential since it makes the use of draught animals independent of the hire market. This option is discussed more fully later.

There, thus remains an ample economic basis for broadening once more the scope of water buffalo in small-scale farming, allowing it to regain a proportion of the acreage currently ploughed by tractor. However, policies designed to achieve this switch need to proceed cautiously. Soil and agro-climatic parameters limit the area of substitutability between animals and tractors: for example, buffaloes are likely to show an advantage only where pre-wetting of the soil takes place[1] and where tillage does not require a high horse power per power unit. Similarly, there is an opportunity cost, often unconsidered, in making stored tank water available for pre-wetting for buffalo ploughing in terms of what the water could otherwise be producing (in a Yala season, for instance). Finally, and probably most importantly, policy encouraging buffalo use will be effective only if there is confidence that farmers themselves will be prepared to make the necessary effort to change after having become accustomed over a number of decades to the ease of tractor tillage. In other words, if the farmer is to be expected to resume buffalo ploughing, policy has to be designed to make it worth his while.

3. BUFFALOES AND TRACTORS IN AGRICULTURE

The current importance of animal power in land preparation varies according to the differing distribution of resources (viz. labour, animals and tractors) amongst the three major agro-climatic zones on the island. As the figures in Table 3 indicate, tractorised land preparation, at almost 70% of the cultivated acreage, is a distinctly Dry Zone phenomenon which reflects (in addition to the rainfall, land holding size and labour density characteristics of this area) a lower buffalo/paddy land ratio compared to the rest of the island (Table 4).

While the Dry Zone accounts for 62.1% of the total asweddumised acreage it supports only 52.4% of the national herd. The power shortfall for paddy production under the present usage pattern of buffaloes is partly redressed by the greater number of tractors available for cultivation

[1] Either by rainfall or by water issues from the Tank.

in this zone. It is therefore logical that, if tractors were to be widely used in small farm systems, the Dry Zone would be the first place where they would gain a foothold.

The smaller land holdings and higher buffalo and labour densities per unit of paddy land in the Wet Zone account for the low use of tractors in tillage in preference to mammoty and animal power. The abundant grazing found in the coconut growing areas of the Intermediate Zone (particularly in Kurunegala District) explains to some extent the high proportions of buffalo/ paddy land density (157.9 pairs per thousand acres of asweddumised land) on the island. However, it must be noted that Farm Power Survey data record higher buffalo densities among Dry Zone colonisations schemes, which indicate the exteht of variation concealed by aggregrate national and regional figures (see Table 8).

Table 3 : Percentage of Annual Paddy Acreage Ploughed by Power Source

Zone	Mammoty	Animals	Tractors
	%	%	%
Wet	48	42	10
Intermediate	7	63	30
Dry	4	26	70
Sri Lanka	18	37	45

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

Table 4 : Availability of Farm Power

Zone	Wet	Intermediate	Dry	Sri Lanka
Asweddumised acreage (1978/79)	377975	261399	1046226	1685600
% distribution	22.4	15.5	62.1	100
Effective number of power units available for cultivation:				
Buffalo pairs[1]	39020	41280	88440	168740
%	23	25	52	
2-wheel tractors	1800	1080	4860	7740
%	23	14	63	
4-wheel tractors	950	1330	4560	6840
%	14	19	67	
Density of draught pairs per 1000 acres asweddumised land	103.2	157.9	84.5	100.1

Note :

1. Despite reservations concerning the true size of the national herd, we have already stated the case for accepting the higher estimates on which these figures are based.

Source : Farrington et al (1980b).

4. THE BUFFALO POPULATION

Any policy designed to encourage buffalo usage for draught purposes is immediately beset with the problem of a confused statistical base. Figures in Sri Lanka vary widely both on the current size of the national buffalo population and on its rate of change: either deficiency renders estimation of the current draught buffalo supplies dependent on often questionable assumptions.

The Department of Census and Statistics provides an annual estimate of the buffalo population which indicates a slowly expanding herd numbering

844000 in 1979. These annual figures have conventionally been regarded as inaccurate. A second source of information on the national herd is the Agricultural Census conducted in 1962 and 1973 (Table 5).

Table 5 : 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 N.L.D.B. published projections.
3. Annual survey figures.

According to the Census data, the buffalo population has declined between 1962 and 1973 at an average of 4% per annum, giving a current 1980 projection of 286000 head of buffalo(based on this rate). A more optimistic rate of herd decline is 0.7% per annum used by the National Livestock Development Board (NLDB,1979), which results in a current estimated buffalo population of 363000. However, the DCS Annual Livestock Survey figure is greatly in excess of Census-based projections. The evidence from a number of recent studies suggests that there are grounds for placing rather more reliance on the Annual Survey estimates than on the Census data, though both estimates may be wide of the mark. For instance, in a house-to-house census conducted recently by the NLDB in the Kuliyapitiya electorate of Kurunegala District, buffalo population figures were found to correspond closely with Annual Survey figures when extrapolated to a District basis. Similarly, a survey conducted by the Department of Animal Production and Health at Peradeniya within a number of Agrarian Service Centre areas suggests that for some districts the Annual Survey estimate is a more reliable measure of actual livestock populations (Richards and Agalawatta, 1980).

Even at the most optimistic estimates of the current buffalo population, some substantial reduction since the peak of the mid-sixties is indisputable. 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 under a certain age 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 2580 and 4000 respectively, it is felt that the actual national rate of slaughter is in excess of 20000 head per annum (Burch, 1979). Two further factors contributing to a decline in the national buffalo herd have been reductions in the available grazing area, and the spread of tractorisation as a substitute for, rather than a supplement to, buffalo draught power. These have taken place particularly in the Dry Zone where over half the total herd is located. Perhaps the only statement concerning buffalo stocks that can be made with confidence is that until the quality of the statistical base is improved the success of many planning decisions taken with respect to buffalo promotion and tillage requirements will be jeopardised.

5. DRAUGHT POWER OWNERSHIP AND ACCUMULATION OF WEALTH

Perhaps the single most important indicator of wealth in rural communities in the Dry Zone is the amount of land either owned or controlled by individuals. Here we first analyse the relationship between land holding size and buffalo ownership at the national level. We then proceed to examing the extent to which owners of various power types have accumulated land over a period of several years. We suggest that this analysis is useful both in demonstrating that draught animal ownership has a wealth-generating potential, and in highlighting the dangers of rapid and inequitable accumulation of wealth which accompany mechanisation policies, with their inevitable narrow ownership base.

Information on the national distribution of land holding sizes in relation to the average number of buffaloes owned per holding is provided in Table 6. There exists a direct positive relationship between the amount of land a farmer operates and the size of herd under his control: this is not unexpected since ownership of land and animals are both indicators

of wealth. A farmer cultivating a greater acreage under paddy naturally has a greater power requirement for land preparation. A total of 68% buffalo rearing holdings fall within the five acres and less category. In the Dry Zone colonisation schemes the typical land holding allotment is three acres of lowland and two acres of highland. Thus, the 1 to 5 acre category may be considered the modal class for the Dry Zone, characterised by an average herd size of 3.2 buffaloes, which is generally adequate for the seasonal tillage requirements of this acreage.

Table 6 : Distribution of Buffalo Ownership by Size of Land Holding, Sri Lanka

Size of land-holding (acres)	% of buffaloes	% of buffalo rearing holdings	Average herd size per holding
No land			3.6
0 - 1	7	11	2.4
1 - 5	48	57	3.2
5 - 10	32	23	5.1
10 +	13	9	7.0
All sizes	100	100	3.8

Source : Agricultural Census, 1973

The ownership of herd sizes of the magnitude recorded in the survey (Table 8) has created opportunities for buffalo owners to deploy their spare draught assets in the custom hire market and to gradually extend the area of land under their control. Evidence from the Farm Power Study indicates that the rate of land accumulation over time has been modest for buffalo owners in comparison to tractor owners (Table 7), though substantial in comparison to non-owners (at Kaudulla and Padaviya).

In absolute terms, buffalo owners at each location recorded larger acreages under their control than non-owners during Maha 1978/79, while at Kaudulla and Padaviya the size of the average land unit varied according to the horsepower of the draught unit: 4-wheel tractor owners controlled land which exceeded that of buffalo owners by factors of

1.4 and 3.5 respectively. The rate of land accumulation is similarly ranked by ownership of power type: highest for 4-wheel tractors owners and lowest for non-owners.

Only at Uda Walawe were reductions in acreages controlled recorded for all owner categories. It is suggested that the process of colonisation in this already well-established farming area required some farmers to forfeit a certain extent of land already in their possession (Abeyratne and Farrington, 1981).

The more rapid rate of land accumulation achieved by tractor owners (particularly 4 w.t.) is facilitated by the potential of tractors to plough land rapidly and early, and consequently to absorb a proportionately greater amount of the hire work available. We would suggest that this facility of tractors is attributable both to organisaional and to technological factors. In many circumstances it would be technically possible to plough an acreage similar to that cultivable by a single tractor by means of a sufficiently large animal herd, but the organisational difficulties of feeding and ploughing would be far greater.

Clearly, the distinction between acceptable and unacceptable rates of wealth accumulation, and between those which are and are not accompanied by expropriation of resources belonging to the weaker members of the community, will depend to some degree on value judgements. Whilst few would find a moderate accumulation of production-generated wealth contentious, the rapid rates of accumulation attributable to the highly concentrated ownership of farm power are a source of concern. The policy which we would recommend, involving the broader-based ownership of small units of power (specifically, 2 or 3 draught animals per household), would reduce costs to the farmer and to the national economy. Simultaneously, it would raise farm incomes by providing an earnings opportunity through the hire market and remove the dangers of unbalanced wealth accumulation.

Table 7: Land Accumulation by Category of Owner

	Extent of land controlled in: Year of Arrival (acres)	Maha 1979/80 (acres)	% change
UDA WALAWE			
4 w.t. owners	3.93	3.06	- 22.1
2 w.t. owners	2.48	2.30	- 7.3
Buffalo owners	4.42	3.16	- 28.5
Non-owners	3.50	2.41	- 31.1
KAUDULLA			
4 w.t. owners	3.13	7.96	+154.3
2 w.t. owners	3.66	5.76	+ 57.4
Buffalo owners	4.61	5.53	+ 20.0
Non-owners	4.21	3.33	- 20.9
PADAVIYA			
4 w.t. owners	8.05	17.09	+112.3
2 w.t. owners	4.22	8.57	+103.1
Buffalo owners	3.84	4.92	+ 28.1
Non-owners	3.05	3.69	+ 21.0

Source: Abeyratne and Farrington, 1981.

6. ANALYSIS OF FARM POWER SURVEY FINDINGS

The ARTI/Reading University study team is paying close attention to economic factors in the timing of seasonal cultivation in Dry Zone major irrigation. A number of important trade-offs are involved: by bringing forward the start of the agricultural season and synchronising the cultivation calendar among farmers, more efficient use can be made of water resources (both rainfall and tank water). The prospects for extending the area of cultivation or increasing the cropping intensity are therefore improved. At the same time, however, improved synchronisation raises the peak demand for certain inputs, particularly draught power, as does the attempt to cultivate rapidly with the onset of seasonal rains. Such measures as these are not cost-free, and the costs incurred must be weighed against the potential benefit of increased agricultural production.

A major area of difficulty in attempting to assess where the net advantage lies is in defining the scope for substitution among the draught power types, and between power and water. Further, it is not only the production impact of alternative power types under various water regimes which is at issue. Such other effects as those on employment and the distribution of income and wealth impinge on the common good and require examination.

Our aim in this and subsequent sections is a relatively modest one within this context. It is to describe and analyse the observed characteristics of buffalo ownership and use so that these can be taken into account in a subsequent broader analysis of farm power.

We present below some preliminary results of research relevant to buffalo usage. These are drawn from field surveys covering two agricultural seasons conducted at three major irrigation schemes:Padaviya, Kaudulla (including Minneriya) and Uda Walawe. It is felt that there is sufficient variation in agricultural characteristics displayed by this group of schemes to permit relevant and applicable conclusions to the drawn for major colonisation in the Dry Zone and for general farm power analysis.

6.1. Buffalo Density and Ownership Characteristics

Table 9 displays a number of interesting differences in buffalo densities (per thousand acres of paddy land) both between the four colonisation schemes, and between tracts within each scheme. Padaviya has the highest density of buffaloes,which is probably attributable to the continued availability of abundant grazing in surrounding jungle areas. Both Kaudulla and Minneriya have very much lower buffalo population densities, which partly reflects the limited availabilty of free range grazing land in this well-established paddy growing area of Polonnaruwa District. What is significant in these two schemes is that it has been possible to sustain substantial buffalo numbers under a management system very different from that practised in most of the Dry Zone. Grass and forage is generally cut and brought to the animals tethered at the homestead, a system which is compatible with the large contiguous areas of paddy (approximately 60000 acres)found in this area, with grazing land available only at the peripheries. Contrasts between differing management systems for buffalo will be discussed later when the authors examine some of the implication of their recommendation for herd expansion.

Uda Walawe, in the southern part of the island, is an area which to a limited extent has within its boundaries forest areas suitable for supporting large herds of buffaloes at certain times of the year. Buffalo rearing is a long-practised traditional activity in this area, which accounts for the larger herd sizes found there, whereas at Padaviya the stock of domesticated buffalos started to increase only since the commencement of colonisation in the late 1950's. It is interesting to note that at Uda Walawe tillage techniques are limited frequently to rudimentary trampling of the flooded liyaddes by teams of buffaloes,a practice which is partly attributable to the boggy soil conditions there, but which may be also be explained by the reduced degree of management skill this type of cultivation requires, and hence its greater compatability with large individual herds.

Whilst the density of tractors could be expected to vary according to the distribution of income and wealth within irrigation schemes (and

Table 8: Buffalo Densities and Ownership Concentration in Four Selected Colonisation Schemes, 1980.

Scheme	Total No. of buffalos	Buffalo density per '000 acres paddy land	No.of adults per owner
1. PADAVIYA*			
Tracts: 1-5	1922	811.7	16.2
A-D	923	424.6	15.9
6-10	3410	782.2	17.7
E	1499	743.6	7.2
11-13	475	345.7	12.8
All tracts	8229	668.0	13.2
2. KAUDULLA**			
Stage I : Tracts 1-4	723	283.5	3.1
: 5-9	862	418.6	3.3
II: Tracts 1-6	654	226.6	2.5
7-12	923	302.7	2.8
Stage I & II	3162	299.9	2.9
3. MINNERIYA**			
Stage I	440	70.9	6.8
II	100	367.6	5.9
III	1129	407.9	3.8
IV	890	347.4	3.4
V	764	224.4	4.7
All Stages	3323	218.9	4.2
4. UDA WALAWE*			
Tracts : 2-7	1218	345.1	58.0
Chandrikawewa	1008	219.5	42.0
9-11	1498	633.1	45.4
12-14	1773	384.8	28.6
15-19	911	307.6	26.0
All tracts	6408	364.2	36.6

* Allottees and non-allottees

** Allottees only

Source: Farrington et al (1980b).

wealth is likely to be strongly influenced by water availability, so that distance from the scheme headworks might serve as a good proxy for wealth distribution), the same cannot be anticipated for buffaloes. This is partly because a reduction in their density might be expected in wealthy areas successfully penetrated by mechanisation; partly also because buffaloes are a relatively less expensive form of power with a far longer history in small farming.

Our data confirm a declining density of tractors with increasing distance from the headworks (Farrington et al, 1980b), but variations in buffalo density do not follow any distinct pattern, with the exception of some decline at the tail end of Uda Walawe (Table 8).

The striking differences in buffalo ownership concentration between Uda Walawe/Padaviya on the one hand and Kaudulla/Minneriya on the other correspond with the differences in husbandry practices mentioned above. Where free range grazing land is available herd sizes tend to be larger (in some instances individual herds have been known to number several hundred), whereas with tethering and stall-feeding typical herds number some three or four adults. With the growing pressure on Dry Zone land by people and animals it is clear that any future solution to encouraging a larger buffalo population lies in more intensive integrated cropping / husbandry systems. Such systems, already evident in the Polonnaruwa District and well-established throughout the Wet Zone, offer the advantages of spreading more evenly the distribution of buffalo wealth and improving potential use-efficiencies of draught animals as a result of more closely supervised smaller herds.

6.2. Analysis of Sample Buffalo Herd Characteristics

6.2.1. Age and Sex Analysis

The figures for mean herd sizes in Table 10 indicate that the ratio of adult male to female buffaloes at Uda Walawe, Kaudulla and Padaviya are 1:1, 1:0.6 and 1:1.14 respectively. While the proportion of adult cows appears adequate at Uda Walawe, and is in surplus at Padaviya, the striking surplus of bulls at Kaudulla has serious implications for the rate at which these herds are able to reproduce themselves. At

Table 9 : Changes in Sample Herd Sizes

		Opening stock Aug.1979	Final stock Oct. 1980	Mean herd size	% change
1. UDA WALAWE					
Juveniles	male	87	100	93.5	+15
	female	102	117	109.5	+ 5
Adults	male	291	189	240.0	-35
	female	255	214	234.5	-16
Senile/sick/injured		38	37	37.5	- 3
Total		773	657	715.0	-15
2. KAUDULLA					
Juveniles	male	23	39	31.0	+70
	female	18	31	24.5	+72
Adults	male	104	103	103.5	-01
	female	67	61	64.0	-09
Senile/sick/injured		6	6	6.0	0
Total		218	240	229.0	+10
3. PADAVIYA					
Juvenile	male	56	95	75.5	+70
	female	48	71	59.5	+48
Adults	male	152	112	132.0	-26
	female	192	179	185.5	- 7
Senile/sick/injured		30	26	28.0	-13
Total		478	483	480.5	+ 1

Source: ARTI/Reading University Farm Power Study.

Table 10: Reasons for Change in Herd Sizes

	Reason	Adult M	Adult F	Juvenile M	Juvenile F	Senile/ sick/ injured	Total
1. UDA WALAWE							
IN	Birth	00	00	46	33	00	79
IN	Purchase	00	00	00	00	00	00
IN	Gift	12	06	07	04	00	29
OUT	Died	51	34	40	22	01	148
OUT	Sold as working animal	03	03	00	00	00	06
OUT	Sold for slaughter	00	00	00	00	00	00
OUT	Stolen	60	10	00	00	00	70
	Net change	-102	-41	+13	+15	- 1	-116
2. KAUDULLA							
IN	Birth	00	00	16	12	01	29
IN	Purchase	03	01	00	01	00	05
IN	Gift	00	00	00	00	00	00
OUT	Died	00	01	00	00	01	02
OUT	Sold as working animal	02	04	00	00	00	06
OUT	Sold for slaughter	00	00	00	00	00	00
OUT	Stolen	02	02	00	00	00	04
	Net change	- 1	- 6	+16	+13	0	+22
3. PADAVIYA							
IN	Birth	00	00	64	46	00	110
IN	Purchase	00	05	01	00	00	06
IN	Gift	05	05	00	00	00	10
OUT	Died	26	20	22	22	04	94
OUT	Sold as working animal	13	03	00	00	00	16
OUT	Sold for slaughter	00	00	00	00	00	00
OUT	Stolen	06	00	04	01	00	11
	Net change	-40	-13	+39	+23	-4	+15

Source: ARTI/Reading University Farm Power Study

Kaudulla, where herd sizes average two or three adults, a low growth rate could lead, for instance, to a growing dependence on mechanical draught power in the future. However, Kaudulla herds achieved the highest rate of natural increase over the survey period, due largely to an extremely low calf and adult mortality rate(Table 9).

Juvenile male/female ratios are 1:1.7 at Uda Walawe and 1:0.8 at both Kaudulla and Padaviya. The deficit of young cows recorded in the two latter schemes will reduce the growth potential of the herds.

The ratio of juveniles to adults at Uda Walawe, Kaudulla and Padaviya are 1:2.3, 1:3.0 and 1:2.3 respectively.

6.2.2. Changes in Herd Sizes

The information collected over the survey period provides a useful source of comparison of sample herd parameters (growth, mortality, offtake and calving rates) with national and other estimates, many of which are the subject of debate.

While constant herd growth is frequently assumed for national and zonal buffalo populations (Richards and Agalawatte, 1980; Shaw, Capper and Manser; 1979 for example), herd growth in the Farm Power Survey was found to vary markedly between each study location: a net change of -15% recorded at Uda Walawe, +10% at Kaudulla and +1% at Padaviya. The reduction in herd sizes at Uda Walawe is the result of the combination of a low calving rate (33.7%) and high mortality rate (20.7%), along with a remarkable incidence of livestock theft. Such extremely poor growth parameters can be explained partly by the herd management system practised and partly by inacurrate reporting of deaths by herdsmen to the owners who, due to factors of distance and large size of herd, are poorly placed to verify whether an animal has in fact died naturally or has been sold for slaughter. While calving rates tend to be higher under the open grazing Dry Zone system of "free breeding", with breeding opportunities somewhat reduced under tethering systems, only Padaviya herds record an average calving rate approaching the range of averages shown for comparison in Table 12. The low calving

rate and high calf mortality rate recorded at Uda Walawe(30.5%) are chiefly the result of disease and health conditions there: 78% of the calves born during the survey period died. False reporting aside,this situation is seen largely as a reflection of the management system under which buffalo herds are removed in the dry season to distant areas in search of grazing. Under such circumstances the animals are more susceptible to neglect and disease, and veterinary facilities are thinly spread.

However, while the rate of herd mortality at Uda Walawe may to some extent be over-estimated, the Padaviya figure of 19.6% suggests that high levels of herd mortality, particularly amongst calves, is a feature characteristic of free grazing systems in the Dry Zone. If the Uda Walawe production parameters are to be taken as accurate, an annual rate of natural decline of the order of 10% will have drastic repercussions on draught availability and the production of by-products (e.g. curd) there in the next few years.

An almost negligible rate of herd mortality at Kaudulla (0.9%) and modest calving rate (43.7%) combine to produce a rate of natural increase over the survey period of 10%. The relationship between natural rates of growth, management systems and herd size is clearly evident and in favour of the "Kaudulla" model for the Dry Zone. The rate of sale for draught is highest at Padaviya (3.3%). This is the result of sporadic sales of livestock in response to cash difficulties faced by farmers who lack other employment opportunities and who were unable during the Yala 1980 season to cultivate for want of irrigation water. The Mahaweli Authority is currently purchasing buffaloes in this scheme for transport as draught animals to the new settlement areas in System H. At Kaudulla, 14% of total stock additions were attributable to purchases, and 50% of outgoings to sales of buffaloes as working animals. This perhaps reflects a keen commercial awareness of the value of buffaloes in this paddy surplus area.

A number of other reasons for stock changes are worth mentioning for particular areas, though these are not always related to management systems. At Uda Walawe a substantial proportion of buffaloes (27.6% of total herd additions and 3.8% of total herd size) were received as

Table 11: Selected Sample Buffalo Herd Production Parameters

		Uda Walawe	Kaudulla	Padaviya
Total No. of animals (a)		715	229	480.5
Average herd size		31.1	5.9	18.5
Proportion of: males		0.49	0.60	0.46
females		0.51	0.40	0.54
Herd Incomings				
Natural increase (b)	%	-9.6	10.0	1.2
Calving rate (c)	%	33.7	43.7	59.3
Purchases	%	0	2.2	1.2
Gifts	%	4.1	0	2.1
Herd Outgoings				
Mortality rate: (d)				
Juveniles	%	30.5	0	32.6
Adults	%	17.9	0.6	14.5
Herd	%	20.7	0.9	19.6
Beef offtake	%	0	0	0
Sale as working animal	%	0.8	2.6	3.3
Theft	%	9.8	1.7	2.3

Notes : (a) Calculated as simple mean of beginning and final herd sizes (Table 9).

(b) Births minus deaths.

(c) Calving rates are based on births per adult cow population.

(d) Mortality rates for juveniles and adults are based on deaths per mean total of juveniles and adults respectively.

Also : 1. All calculations are based on the data shown in Tables 9 and 10.

2. Except where otherwise stated, percentage figures are based on total mean herd size.

3. There is some addition error due to rounding.

gifts. The main reason for this is the "Gambaraya" system that prevails in this area, in which those who owned large herds were regarded as community leaders, and would often make livestock gifts to their children as dowries and so on.

The incidence of stock theft is alarmingly high at Uda Walawe, amounting to 9.8% of the total herd population sampled. This type of activity is less easily controlled when herds are grazed freely. Theft rates at Kaudulla and Padaviya are substantially lower.

The sale of buffalo for slaughter is recorded nowhere in the survey, which is at variance with national and zonal beef offtake rates presented for comparative purposes in Table 12. It is quite possible that beef sales do in fact take place but are concealed under other "herd outgoing" headings. Beef sales have frequently been cited as the major explanation for the herd decline between 1962 and 1973 to meet the growing demand for cheap meat. However, the low returns resulting from low beef prices available to buffalo owners for animals slaughtered for meat reduces the incentive to rear livestock in an efficient manner, and this is reflected in general Dry Zone production parameters.

A comparison of our survey herd parameters shown in Table 11 with those produced in another recent survey, as well as with national figures (Table 12), draws attention to a number of interesting differences. Calving rates recorded by Richards and Agalawatte for herds sampled in all three agro-climatic zones are consistently higher than the national average of 40%, and exceed our survey rates at Uda Walawe and Kaudulla. Highest calving rates are recorded for the Dry Zone (71% and 83%)by them.

The rate of juvenile (calf) mortality for the national buffalo population is calculated as 20%. The figure for the free range herds at Uda Walawe and Padaviya is approximately one in three. Zonal mortality rates shown in Table 12 may be underestimates since calf loss often remains unnoticed in free grazing systems. Thus, high calving rates observed amongst Dry Zone herds are partly counterbalanced by the high incidence of calf mortality, normally caused by gastro-intestinal parasites. Adult mortality

Table 12: National and Zonal Buffalo Production Parameters

Zone	Wet		Intermediate		Coconut Triangle	Dry		Sri Lanka
	D	DM	D	D	D	DM	D	
Average herd	2.1	17.8	3.4	5.5	3.4	19.8	9.2	-
Calving %	53	56	62	59	53	71	83	40
Juvenile mortality %	25	3	32	20	13	20		20
Adult mortality %	0	0	1	1	4	12		2.5
Herd mortality %	5	0	9	5	6	15	15	9
Beef offtake %	9	16	12	16	12	11	10	11

Note: D - draught herd only
DM- draught and milk herds

Source: Zonal figures from Richards and Agalawatte, 1980.
National figures from Shaw, Capper and Manser, 1979.

amongst free range herds in the Farm Power Survey are noticeably a higher than national and zonal figures, although high adult mortality is a feature characteristic of Dry Zone herds. Rates of beef offtake are recorded with little variation in Table 12, averaging 11% nationally (in all cases stable herd growth is assumed). Mention has already been made of the absence of buffalo sales for slaughter amongst sample herds. Even if livestock thefts were included in the offtake category, the resulting offtake figure would remain substantially below the national average. It can only be presumed that buffalo owners were reluctant to divulge information concerning beef sales for tax avoidance reasons.

6.2.3 Implement Ownership

Although performance data from the ARTI/Reading University study are not yet available, evidence from other parts of the region[1] indicates that the transition from systems in which buffalos merely churn the soil by trampling to one in which they are equipped with ploughs is accompanied by substantial improvements in performance. If similar efficiency gains can be obtained in Sri Lanka's Dry Zone, there is

1. Bulletin 10, Reading Rural Development Communications, AERDC, Reading Univ.

much in favour of the introduction of ploughs. In Dry Zone conditions, the advantage would lie not only in performance gains from the existing farm power stock, but also potentially in the reduction of water consumption during land preparation: the inundation of paddy fields is essential to trampling but not to ploughing systems. Only in rare instances where the opportunity cost of water is zero would there be no potential advantage of introducing low cost water-saving techniques.

One further point deserves mention: there is a strong trade-off between herd size and efficiency, insofar as buffalo owners will find difficulty in keeping large herds fully occupied if they are to be split up into plough- equipped pairs. With trampling, 8 or 12 animals can be used simultaneously on the same small plot and, therefore, on the same hire contract. Organisational simplicity is being traded off against production efficiency where herd sizes are large, and to us this appears to constitute a strong argument in favour of small herd sizes.

The ownership of draught implements is closely related to a number of variables, viz. the number of working animals, the range of field operations performed, soil conditions and so on. An immediate difference between implement ownership per adult buffalo is evident between Kaudulla and the remaining locations. An average of 2.5 ploughs (both country and semi-mould board variety) and 1.7 levelling boards are owned by each farmer in Kaudulla, which is more than adequate for the number of draught buffalo pairs per herd there.

Ploughing at Uda Walawe is rare. Farmers prefer to trample waterlogged fields with teams of buffaloes, which reduces the need for implements. A combination of trampling and ploughing is practised at Padaviya where average herd size are somewhat smaller. An average of 2.3 ploughs and 1.5 levelling boards per farmer were recorded at Padaviya although the low concentration of implement ownership per draught pair indicates the extent to which trampling methods are preferred.

Table 13. Implement Ownership

Location	No. of ploughs	No. of levelling boards	No. of adult buffalos	No. of farmers who own ploughs and level boards	
1.Uda Walawe	20	01	474	04	01
2.Kaudulla	97	67	167	39	39
3.Padaviya	43	17	317	19	11

Source: ARTI/Reading University Farm Power Study.

6.2.4 Inter - Locational Comparisions of Physiological Characteristics

As far as draught purposes are concerned, the weight and condition of animals are of prime importance. The study team, comprising mainly economists, were not qualified to make anything more than casual observations on the animals' condition. However, it was thought worthwhile to make more systematic observations of their size, particularly since differences between the management systems at Kaudulla, on the one hand, and Padaviya and Uda Walawe on the other, might have a significant bearing on standards of nutrition and ultimately on the size of animal.

Girths measurements were therefore taken for a sub-sample of adult male buffaloes at each location. The mean girths and numbers of observations were as follows: Uda Walawe 68.52 inches (n=130); Padaviya 66.94 inches (n=176); Kaudulla 69.18 inches (n=88).

Although the average buffalo at Kaudulla appears to be slightly larger, the difference is small and is unlikely to reflect any impact of management systems on size of animal. Significance tests suggested that the Kaudulla figure is not significantly different from that at Uda Walawe at 5% level. On the other hand, the differences between Kaudulla on the one hand and Padaviya and Uda Walawe on the other are significant at the 5% level.

These significance tests notwithstanding, perhaps the only safe conclusion is that stallfeeding certainly does not produce animals of inferior size compared with open grazing. We would argue that it

has the potential (given better quality feeds) to produce much larger animals. Whether this potential can be exploited remains to be seen.

6.3 Age Patterns of Buffalo Owners

We can, to some extent, attempt a reply to a query raised in the introduction concerning the willingness of farmers to respond positively to any moves directed towards encouraging greater buffalo use in farming. Critics may argue that the traditional methods of animal-powered land preparation have little appeal to modern farming men today. If the young are committed to tractors then the prospects may not be as optimistic as considerations of cost and high quality of tillage would suggest . We have examined the issue of the age- structure of both buffalo and buffalo hirers in order to detect whether any patterns emerge.

Using a criterion of 40 years of age to distinguish between young and old farmers, it emerged from our survey that at all locations a higher percentage of buffalo owners were 40 or over than were tractor owners. Thus, while buffalo owners do tend to appear to be predominantly older men than tractor owners, the difference is small and may prove to be statistically insignificant.

An analysis of buffalo and tractor users(i.e. those hiring in, as well as owners) indicated no clear age bias. However, the analysis of users is beset with a problem of identification, since the use of more than one power type in land preparation is common , making it impossible to satisfactorily classify farmers as using exclusively one or another power type. For the present discussion, users were classified as those who own buffaloes plus those who hired them in for at least one operation in Maha 1979-80. When both owners and hirers of power were considered together the trend of a relatively high age structure of buffalo users recurred (Table 14) but even more weakly than for owners alone.

Table 14. Percentage and Numbers of Combined Power Users and Owners over 40 years by Power Type and Location (Land Preparation).

	Buffalo		4 w.t.		2 w.t	
	%	No.	%	No.	%	No.
Padaviya	80	72	75	58	57	18
Kaudulla	75	76	53	9	68	17
Uda Walawe	81	46	50	3	79	26

Source: ARTI/Reading University Farm Power Study.

We conclude that there are only weak indications that the ownership and use of buffalos is more widespread amongst older farmers than younger farmers. The observed age- profiles of owners indicate that young farmers are still well-represented in the buffalo ownership category. As far as policies to promote animal draught are concerned, it is imperative to harness and build upon such residual enthusiasm as this for animal draught among young farmers.

6.4 Use Patterns of Draught Buffalo

Crucial to any policy of encouraging buffalo use in agriculture is the question to what extent are animals already used in farming? Is it a residual activity encountered among only a small proportion of farmers, or does it remain widespread?.

The data persented in Table 15 suggest that buffaloes are more widely used for at least part of the land preparation sequence than any other power type, whilst in threshing it is over-shadowed by the 4-wheel tractor.

Table 15. Percentage of Farmers Using Individual Power Types by Location (for at least part of land preparation and threshing).

	Kaudulla (N=145)		Padaviya (N=144)		Uda Walawe (N=145)	
	%	No.	%	No.	%	No.
a) Land preparation						
Buffalo	70	102	63	90	39	57
4 w.t.	12	17	53	77	5	6
2 w.t.	17	25	16	23	23	33
b) Threshing						
Buffalo	17	25	15	21	0	0
4 w.t.	49	71	54	78	63	92
2 w.t.	0	0	0	0	0	0

N.B. A certain number of farmers practised hand cultivation.
Source: ARTI/Reading University Farm Power Study.

The use of buffaloes for at least part of land preparation remains very widespread. This is probably explained by farmers' apparent preference for buffaloes in finishing off and levelling their fields, frequently after an initial rough tilling by tractor. It is particularly noticeable that many more farmers were able to use buffaloes at Kaudulla (70%) than elsewhere in spite of a lower overall buffalo density. This may be accounted for by the observed widespread ownership of small numbers of animals per owner, and the absence of the organisational problems that might be anticipated elsewhere (at Uda Walawe, for example) in arranging a full work programme for large herds.

We consider next the information gathered in our survey concerning the intensity with which draught buffalos are utilised amongst our sample owners.

The data on average number of hours worked by buffaloes per week presented in Table 17 below are drawn from research observations of buffalo use-patterns covering the first twenty weeks of the Farm Power Survey: included

in this is the entire Maha 1979-80 land preparation season at all locations, covering the busiest period in the agricultural calendar. The data are presented by spatial location within schemes in order to reflect the effects of water availability on use patterns. The attempt was also made to determine whether the owner's main occupation (whether farming or some other business) influenced use levels.

6.4.1 Hours Worked by Study Location

The overwhelming impression of the figures presented in Table 16 is one of very low use intensity of buffaloes. While the figures vary markedly within schemes the total number of hours worked is remarkably consistent amongst the three study locations, averaging between 6½ and 7 hours per pair per week. These figures include work performed at the busiest time of the year(i.e. Maha land preparation)and thus the average over a 12 month period would be much lower. The peak weekly average was found to be 17-22 hours per pair , though this was seldom sustained for more than two or three weeks. Even if one were to assume that the land preparation season numbered ten weeks, during which time all the work recorded in Table 16 was performed, the resultant average of roughly 14 hours per pair per week at the peak land preparation season can still be considered far below the maximum potential of draught buffalo capacity, which might lie in the region of about 20 hours per week.

6.4.2 Hours Worked by Spatial Distribution of Ownership

Of all the study locations, Uda Walawe owners record simultaneously both the highest and the lowest extremes of buffalo use intensity at the top and bottom ends of the scheme (10.7 and 4.04 hours respectively). The variation in hours worked is fairly strongly related to differences in water availability between upper end lower tracts. Padaviya displays the opposite relationship between the number of hours worked and distance from the tank headworks, making any general statement about buffalo use in relation to water availability impossible. The low concentration of tractors at the bottom end of Padaviya might explain the higher use intensity of buffaloes there, given the seasonal

demand for tillage power requirements.

Differences in access to irrigation water are small at Kaudulla for reasons already mentioned and this tends to correspond with the lack of variation in work rates recorded at top and bottom tracts there.

6.4.3. Hours Worked by Category of Owner

Owners who derive a major part of their income from business activities record higher use intensities for their buffaloes at Kaudulla and Uda Walawe, achieving a maximum of 14.42 hours per week at the latter scheme. This difference corresponds with a general notion that owners who are business-oriented have greater incentives and opportunities to employ their income-generating assets productively. The absence of businessmen owners at Padaviya is probably a reflection of the relatively underdeveloped commercial non-farm sector there.

6.4.4 Hours Worked for "Self" and on "Loan/Hire"

Data on the division of work between owners' own personal farming requirements and contract work are presented in Tables 16 and 17. No consistent pattern emerges for all three locations. While contract work at Uda Walawe absorbs nearly all of buffalo working time for both owner categories, the reverse is true at Kaudulla. This may be partly explained by the large herds found at the former location in contrast to the smaller herds found at Kaudulla (resulting in a high proportion of "self" work). At Padaviya, farmers hire or loan out their animals for 43% of the recorded working time.

Table 16: Average Weekly Number of Hours Worked by Buffalo Pairs[1]

	Location in Scheme			Owner Category	
	Top	Bottom	All	Businessmen	Farmers
1. PADAVIYA				(N=0)	(N=174)
Self	3.43	4.84	3.75	0	3.75
Loan/hire	2.14	5.16	2.83	0	2.83
Total	5.57	10.00	6.58	0	6.58
2. KAUDULLA				(N=13.5)	(N=75.5)
Self	6.57	6.54	6.55	6.65	6.52
Loan/hire	0.68	0.24	0.37	0.87	0.25
Total	5.75	6.78	6.92	7.52	6.77
3. UDA WALAWE				(N=20.5)	(N=230.5)
Self	0.64	0.04	0.31	0.55	0.33
Loan/hire	9.43	4.00	6.49	13.87	5.83
Total	10.07	4.04	6.80	14.42	6.16

[1] Based on a 20 week period from 26/8/79 to 19/1/80 covering the Maha season.

N refers to the number of buffalo pairs.

Table 17: Percentage of Use Hours per Buffalo Pair Spent on Contract Work by Owner Type.

	Owner category		
	Businessmen	Farmers	Total
	%	%	%
Padaviya	0	43	43
Kaudulla	12	4	8
Uda Walawe	96	95	96

Source: ARTI/Reading University Farm Power Study

From the data displayed in Tables 16 and 17 it may be deduced that the extent to which a team of draught buffaloes perform contract work is dependent on the size of the herd: the larger the herd size owned the greater the likelihood animals will be made available on the power hire market.

However, any future policy decisions on the size of the national buffalo population in relation to power requirements for seasonal land preparation will have to take cognisance of the fact that buffaloes in Sri Lanka are severely under-utilised.(It may be of interest to note that the level of use-efficiency for tractors is little better - See Farrington et al, 1980b).

7. ANALYSIS OF BUFFALO HERD PROFITABILITY

In this section a hypothetical buffalo herd operating budget is assembled in which the major revenue-earning activity, draught work, is isolated from the remaining cost and revenue components of herd maintenance. We present also in Table 18 values for specific expenditure and production items recorded from buffalo owners in the Farm Power Survey. The data presented show the average annual costs incurred by buffalo owners for herd and driver labour and for the purchase and maintenance of equipment feed and medicines.

The figures are preliminary and require cautious interpretation: they conceal for instance the frequently seasonal nature of expenditure and the important uncosted role of family labour in herd management. Furthermore, herding and payment practices vary between study locations. At Kaudulla a large number of small herds are frequently pooled under the care of a single herder during the off-peak months when land preparation and threshing have been completed, and for this a monthly payment per animal is contributed by the owners. At Uda Walawe and Padaviya the larger herd owners are able to employ full-time herders to take care of the herds in the jungle areas and "villus" (river valley grass land); for this service herders may receive a cash wage or a number of calves born to the herd during their employment.

Annual average operating costs are shared between hired labour wages and equipment repair costs. Hired labour costs form the major component of herd expenditure (Table 18). This is made up of a fixed component paid to herders (where family labour is not involved) irrespective of the herd's level of production, and a variable component paid to drivers and operators during the performance of field work.

Although there is a distinct variation in the amounts spent by herd owners on labour wages per animal between each location, no readily discernible pattern emerges in relation to herd size. Padaviya buffalo owners pay an average of Rs.2353.12 herding costs per herd per annum in comparison to Rs.373.88 at Kaudulla and Rs.975.44 at Uda Walawe. When these payments are adjusted for the number of man-months worked and for herd size the labour costs paid per animal-month (Table 18) suggest

Table 18. Average Annual Buffalo Operating Costs and Revenue

	Padaviya	Kaudulla	Uda Walawe
No. of sample herds	26	39	23
Average herd size	18.5	5.9	31.1
No. of draught animals per herd[1]	12.2	4.3	10.4
Hired Labour Costs			
1. Herding			
(a) No. of man-months per herd	8.2	2.2	4.1
(b) Hired herding costs			
Per animal (Rs.)	127.20	63.37	31.36
Per herd (Rs.)	2353.12	373.88	975.44
Per animal/month (Rs.)	15.36	29.34	7.09
Per herd/month (Rs.)	284.19	173.09	230.03
2. Driver/Operator			
(a) Man-days worked per herd	24.50	14.5	18.6
(b) Average daily wage (Rs.)	14.84	14.15	11.61
(c) Driver costs			
Per animal (Rs.)	19.65	34.82	6.96
Per herd (Rs.)	363.58	205.46	216.53
3. Total Hired Labour Costs			
Per animal(Rs.)	146.85	98.19	38.32
Per herd (Rs.)	2716.70	579.34	1191.97
Equipment and Repair Costs			
Per animal (Rs.)	6.79	42.63	40.06
Per herd (Rs.)	125.59	251.54	1245.84

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[1] Includes male and female adults, except at Uda Walawe where only males are used for draught.

Table 18 continued

	Padaviya	Kaudulla	Uda Walawe
Revenue			
1. Curd and milk sales			
Per animal (Rs.)	0.87	0.25	48.01
Per herd (Rs.)	16.13	1.46	1493.23
2. Hiring out for custom work (estimated)			
(a) Estimated no. of hire hours per pair[1]	143	27	320
(b) Hire revenue[2]			
Per draught pair (Rs.)	715	135	1600
Per herd (Rs.)	4361	290	8320

Notes:

1. Assumed each buffalo pair works 333 hours p.a. (FAO,1980). The proportion of this annual usage devoted to contract work is calculated from Table 18.

2. Calculated at rate of Rs.5 per hour per pair (or Rs.25/day).

that substantial economies of scale are enjoyed by larger herd owners. The use of family labour for herding is more widespread at Uda Walawe and Kaudulla, where the number of man-months of hired herd labour ranges from two to four each year. Average monthly wage paid including kind vary from Rs.173.09 at Kaudulla to Rs.239.08 at Uda Walawe and Rs.284.19 at Padaviya.

The rate at which driver/operators are hired by buffalo owners varies between schemes in a manner similar to the order of magnitude of hired labour for herding. The general impression given by the figures in Table 19 is the greater importance of Padaviya herd owners as a source of local employment in an area where off-farm employment opportunities are scarce.

The average annual outlay per animal on equipment and repair costs (ropes, medicines, ploughs and harnesses) is highest at Kaudulla, at Rs.42.63, and lowest at Padaviya, at Rs.6.79. This type of expenditure varies in direct proportion to the level of work performed by animals, to the type of capital investment per animal, and to tillage practices (puddling or ploughing), and no evident economies of scale are discernible under this heading.

The importance of commercial dairy activities at Uda Walawe as a source of revenue is evident. Equally important as a source of revenue is the potential income derived from hiring out of buffaloes for custom work, which accounts for 96% of total work time amongst the large Uda Walawe herds, 43% for Padaviya herds, and only 8% for the small-size herds at Kaudulla.

The potential annual revenue that can be earned from buffalo ownership varies directly with herd size. In this following section an attempt is made to evaluate the profitability of owning and operating a buffalo herd, using a conventional input-output methodology for examining cost and revenue data.

Table 19. Annual Cost and Revenue Flows from Buffalo Draught Activities (high performance rate:3 1/3 days/acre)

	Tethering/ stall-fed	Free grazing	
	A	B	C
Herd Size	4	20	40
No. of draught animals	2	10	20
Unit	Rs.	Rs.	Rs.
A. Costs from own farm work (2.5 acres)			
1. Buffalo value[1]			
tillage[2]	312	312	312
threshing[3]	375	375	375
Labour value[2] (Rs. 20/man-day)			
tillage[4]	250	250	250
threshing[5]	300	300	300
Sub total costs			
B.Revenue from custom work[9]			
1. Buffalo pair rental (Rs.25/day) for:			
35 days	875	3062	3500
60 days	1500	5250	6000
2. Labour[7]	-	-	-
C.Revenue (i.e. costs saved) through not hiring the following:			
1. Buffalo + labour	1237	1237	1237
2. Tractor(Rs.450/acre)	1687	1687	1687
Sub total revenue			
(a) 35 day rental+C.1	2112	4299	4737
(b) 35 day rental+C.2	2562	4749	5187
(c) 60 day rental+C.1	2737	6487	7237
(d) 60 day rental+C.2	3187	6937	7687

Return on Capital Investment per Draught[9]	Herd	Animal	Herd	Animal	Herd	Animal
(a) 35 day rental+C.1	2277	1138	4922	492	-3072	-154
(b) 35 day rental+C.2	4492	2246	7137	714	- 857	- 43
(c) 60 day rental+C.1	5356	2678	15692	1569	9234	462
(d) 60 day rental+C.2	7569	3784	17908	1791	11449	572

Table 20. Annual Cost and Revenue Flows from Buffalo Draught Activities (low performance rate: 8 days/acre)

	Tethering/ stall-fed	Free grazing	
	A	B	C
Herd Size	4	20	40
No. of draught animals	2	10	20
Unit	Rs.	Rs.	Rs.
A. Costs from own farm work (2.5 acres)			
1. Buffalo value[1]			
tillage[2]	750	750	750
threshing[3]	375	375	375
2. Labour value(Rs.20/man-day)			
tillage[4]	600	600	600
threshing[5]	300	300	300
Sub total costs	2025	2025	2025
B. Revenue from custom work[6]			
Buffalo pair rental (Rs.35/day) for:			
1. 35 days	875	3062	3500
60 days	1500	5250	6000
2. Labour[7]	-	-	-
C. Revenue (i.e. costs saved) through not hiring the following:			
1. Buffalo + labour	2025	2025	2025
2. Tractor (Rs.450/acre)	1687	1687	1687
Sub total revenue:			
(a) 35 day rental+C.1	2900	6087	5525
(b) 35 day rental+C.2	2562	4749	5187
(c) 60 day rental+C.1	3525	7275	8025
(d) 60 day rental+C.2	3187	6937	7687

Return on Capital Investment Per Draught[9]:	Herd	Animal	Herd	Animal	Herd	Animal
(a) 35 day rental+C.1	2277	1138	4922	492	-3072	- 154
(b) 35 day rental+C.2	613	306	3259	326	-4735	- 237
(c) 60 dat rental+C.1	5356	2678	15692	1569	9234	462
(d) 60 day rental+C.2	3690	1845	14029	1403	7570	378

NOTES ON TABLES 19 AND 20

1. Refers to the opportunity cost of not being able to hire out. In all calculations the daily rental for a buffalo pair is Rs.25, exclusive of labour. The daily labour wage is Rs.20.

2. 2.5 acres/Maha + 1.25 acres/Yala, at Rs.25 pair per day.

3. Threshing rate is 0.25 acres/day.

4. (2.5+1.25) x 3 1/3 man-days at low performance rate, and (2.5+1.25) x 8 man-days at high rate.

5. 3.75 acres x 4 man-days for threshing.

6. It is assumed utilisation rates decline with herd size. Factors used for herd sizes of 4,10 and 20 are 1.0, 0.7 and 0.4 respectively.

7. Labour supplied by farmers hiring in buffaloes.

8. Refers to the value saved through not having to plough own land by rented in buffaloes or by tractor. In the former case, the value saved is identical to A, the opportunity cost of not being able to hire out buffalo.

9. Calculated as the net present discounted value (revenue less costs) of the returns to buffalo draught work over the animal's useful working life. (8 years) Purchase price of a buffalo pair is Rs.2030.

Table 21. Annual Cost and Revenue from (non-draught) Buffalo Maintenance

	Tethering/ stall-fed	Free grazing	
	A	B	C
Herd size	4	20	40
Unit	Rs.	Rs.	Rs.
Expenditure			
Ropes, equipment and maintenance[1]	116	580	1160
Herdsman (10 months)[2]	2240	2240	2240
Feed[3]	500	0	0
Veterinary[4]	0	0	0
Total	2856	2820	3400
Production			
Milk and curd[5]	0	1341	2682
Manure[6]	48	41	82
Beef sales[7]	0	0	0
Total	48	1382	2764

NOTES ON TABLE 21

1. Estimated at Rs.29 per animal per annum (Table 18).

2. Average monthly wage for herdsman is estimated at Rs.224 (Table 18).

3. Few Dry Zone farmers provide concentrates or rent pasture for their herds. For tethered herds (A), grass is cut and carried to the animals: the labour effort required is included in the annual costs, including family labour.

4. Veterinary expenditure is generally negligible (Table 18).

5. Assumes 30% of herd are milk cows, with average milk yield of 149 litres/yr., valued at Rs.2/litre (Richards and Agalawatte, 1980).

6. Manure has no economic value in many parts of the Dry Zone, except in the North where it is used extensively in subsidiary crop production. In our calculations manure is valued at Rs.12 per animal per year (Richards and Agalawatte, 1980). For free-grazed herds a weighting factor of 0.17 is used since for 10 months in the year herds are grazed away from the homestead.

In Table 19 and 20 cost and revenue data are estimated for three different herd sizes with the objective of comparing the returns to small and large draught herds resulting from annual land preparation. The herd sizes correspond approximately with average herd sizes recorded in each of the survey locations. A weighting factor has been used in calculating revenue from custom work in order to reflect the relationship between herd size and levels of animal utilisation. Output per draught animal is lower in large herds because the organisational skills required in arranging sufficient contracts to ensure full employment of the whole herd are generally weak.

Cost and revenue flows are calculated for alternative rates of tillage performance and for length of the ploughing season.

Despite the simplistic methodology used, some indication is given of the size of returns resulting from draught work earned by a farmer from his original buffalo investment. Considering first Table 19, the capital return per herd increases with the number of days worked, and in cases where buffaloes have been used for tillage instead of tractors. On a herd basis, capital returns are consistently highest for B(herd size=20). Negative returns are experienced by C (herd size=40) for a 35 day working season, becoming positive over a 60 day period, and exceeding A. This suggests that small herd sizes are more profitable to a farmer than very large herds where the ploughing season is short, although B represents the most profitable herd size under all conditions. On a per animal basis, returns vary inversely with herd size, and the greatest gains are enjoyed by A.

In Table 20, the lower assumed tillage performance rate of 8 days/acre per pair reduces overall returns on investment and alters the ranking of profitability. The reason for this is the cost to the farmer of ploughing an acre of land by tractor now becomes less expensive than by using buffalo and labour. Thus, these farmers substituting tractors for non-mechanised power earn higher returns on their investment. As in the previous table,B records highest returns, and on a per animal basis the advantage lies with the small herd (A).

Table 21 examines production and expenditure items in relation to non-draught activities. Herds labour payments (family labour is costed here on the same basis as hired labour), the major component of expenditure, give rise to distinct economies of scale for larger herd owners. However, we have already noted that small herd owners at Kaudulla frequently pool their animals in a common herd during off-peak months, for which a monthly charge per animal is levied. Milk production is the most important source of income for owners of large herds, and is severely limited by draught requirements for the small herds.

In summary, the scope for achieving greater levels of utilisation amongst buffalo herds numbering two or three draught animals enables the highest rates of return and profitability per animal to be reaped by farmers, in comparison to the returns from large herds.

8. ESTIMATING FUTURE DRAUGHT BUFFALO REQUIREMENTS

Having argued the need to encourage a greater buffalo population to meet annually rising land preparation requirements we discuss here some of the problems encountered in planning exercises designed to estimate the numbers of draught animals that will be needed for tillage purposes. Although this type of farm power planning is essential, its effectiveness is highly sensitive to a number of crucial assumptions on which often vast amounts of aid/loan funds are based.[1] Hitherto, farm power shortages have been postulated on the basis of observed delayed and staggered land preparation, or on the basis of estimating total tractor and buffalo stocks, deducting estimates for breakdowns and non-agricultural work, and thus arriving at the number available for farm work. The use of selected performance rates then permits the potential work output of this stock to be compared with the cultivated acreage: the potential to plough more than the available acreage indicates surplus of farm power, and vice versa. The lack of precision in buffalo population data has already been discussed in Section 4. Assumptions about buffalo field performance rates are dependent on the type of implement used (if any) and its condition, soil condition, water use, and size and condition of the buffalo. Experimental rates are generally higher than those achieved on farmers' fields, since most of these factors are more favourable under experimental conditions.

Assumptions concerning the length of the land preparation season are difficult to quantify, yet the estimation of the tillage capacity of a given herd over time is extremely sensitive to this factor. It is dependent on soil, water and weed conditions, farmers' access to credit and inputs, and on the structure and organisational efficiency of the power hire market.

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[1] For a critique of draught power planning methodologies in Sri Lanka see Farrington et al, 1980c.

We mention briefly here the assumption used by the recent FAO Report of Farm Power Availability (FAO, 1980) in order to illustrate the shortcomings of this type of planning methodology and consider its relevance to draught buffalo in particular.

Table 22: Buffalo Tillage Capabilities

Total number of buffalo pairs available for cultivation	73000
Length of ploughing season (days)	32
Performance rates (acres/day) (full land preparation)	0.154
Calculated acreage capacity	360000
Actual asweddumised acreage	1685600
Acreage capacity of tractor population and mammoties	837144
Estimated farm power deficit (acres)	488456

Source: FAO Farm Power Availability Study, 1980.

We present our own estimates of the national buffalo population in Table 5 along with the reasons for accepting them. On the basis that the number of draught buffalo pairs should be 168740 rather than 73000 and accepting for the moment the FAO assumption of length of ploughing season and performance rates, the tillage capability of the national herd increases by 471551 acres, sufficient to almost fill the farm power "gap" on an aggregate national basis, but with possible regional imbalances.

It is felt also that the assumed buffalo performance rate of 0.154 acres per pair/day may be an under-estimate, though is probably more appropriate to the trampling or mudding systems of tillage practised in the Wet and Intermediate Zones. An alternative estimate of 0.3 acres/day for their use with ploughs, as is common in the Dry Zone, has been suggested by Parker (1978). If accepted, this would add another 340888 acres to buffalo tillage capability. With these two revisions alone a claimed farm power deficit of 488456 equivalent acres is transformed into an apparent surplus equivalent to 1259904 acres: a 29% farm power deficit at one extreme is, at stroke, changed to a 46% surplus.

Thus, there are clearly many imperfections in the current methods of planning the animal component of farm power supplies, which will leave the present role of and future requirements for animal draught open to debate for some time to come.

Yet, cultivated acreages are planned to expand rapidly in the next few years: an anticipated 500000 acres of irrigated land under the Mahaweli Scheme alone will be added to the existing 1685600 acres of asweddumised land. The pressure to arrive at an objective and balanced view of future farm power requirement is therefore pressing. What seems certain is that, if we postulate a stable or declining share of ploughing to be performed by tractors, buffalo populations and use-intensities will, within the next 5-10 years, have to expand at a rate sufficient to plough a higher proportion of the anticipated 2.1 million acres than the present 37.3%.

The policies and problems contingent upon such an intensification are discussed below.

8. CONCLUSIONS AND RECOMMENDATIONS

1. The observed costs of tillage and threshing by animal and tractor power to the national economy (Table 1) present an overwhelming case for expanding the proportion of paddy land tilled by buffalo and for the reducing current levels of investment in tractors. To plough an acre of land by draught animals is far less expensive to the national economy than tractorised ploughing.

Yet, to present a complete picture of the potential costs and benefits to the national economy of the alternative systems requires more comprehensive analysis. Animal draught (buffalo power in particular) is not practicable in hard soil conditions. The area of potential substitution between buffalo and tractors is therefore limited to areas where the soil can be softened by rainfall prior to ploughing (as in the Wet Zone). For the Dry Zone, however, it has been claimed that continued reliance on animal draught would cause high consumption and low productivity use of stored water, and loss of the potential productivity of early rains. Given a sufficiently large animal population, there seems no reason why inter-farm staggering of cultivation should be more severe than with tractors. On the other hand, the fact that animal tillage relies on soil pre-wetting will render animal draught systems overall a late starter in comparison to tractor power.

This is a complex issue which can only be touched upon here. To the best of our knowledge, no recent systematic experimental work on the feasibility and costs of tillage by tractors under completely dry conditions appears to have been done.

Under the Tank Irrigation Modernization Project (" 5 Tanks") a successful Maha crop was raised in 1980-81 by (chiefly) tractor ploughing on the rains at Mahakandarawa Scheme. There seems nothing to prevent animal draught from achieving a similar quality of tilth on the rains, given appropriate implements. The

main constraint to animal draught in a situation such as this appears to be organisational - i.e. can adequate numbers of animals to achieve timely tilling be fed on or near the scheme? Can the hire-market be organised efficiently enough to maintain a steady flow of work for the animals?

Questions such as these would seem to merit attention in experimental and pilot projects in view of the substantial cost savings which would accrue to the national economy if large scale animal-powered rainfed cultivation were to prove feasible.

Additional arguments, impinging on welfare and political issues in the search for an appropriate in farm power supplies, need to be considered, such as: what is the impact on employment and the distribution of income and wealth of tractor vis-a-vis animal systems? Recent evidence from the Farm Power Study is still being processed, but preliminary results place the advantage with animal draught. The effect on land ownership, a major indicator of wealth accumulation, has already been examined above. At a much broader level: what are the implications for national morale and food self-sufficiency of tractor and animal systems? Does the Administration feel that it is worth relying on imported technologies primarily to achieve quick returns, but also because the organisational capacity, initiative and will for self-sufficiency simply no longer exist in adequate quantities to enable animal draught to work on the necessary scale (" no longer exist " because they clearly did exist in earlier Dry Zone civilisations)?

These issues must remain outside the scope of the present discussions: some encroach on the broader areas of political and economic development philosophy and defy empirical analysis; for others, quantitative data are still being assembled under the Farm Power Study. Preliminary indications suggest that an active reconsideration of animal draught is long overdue, and we outline below some issues and policies which require attention.

2. In the short term higher use-levels can be obtained from the existing buffalo population in the following ways:

- by transfer of animals from areas of low use-intensity to areas of high demand
- by improved feedstuffs for stall-fed animals
- by purchasing, feeding and veterinary care schemes for juvenile animals
- by more widespread use of improved and steel-tipped ploughs.

Policies necessary to achieve these objectives hardly need elaboration, though it should be stressed that the current division of Ministerial responsibility between crop production and animal husbandry cannot be conducive to the development of integrated livestock/crop production systems.

3. In the medium term, it is clear that the only future for animal draught lies in systems relying predominantly on stall-feeding, requiring a shift away from the traditional subsistence nature of indigenous low-cost buffalo management systems. Much can be done to establish these in the design of new settlement schemes or in the rehabilitation of old ones (and it is worth noting that a switch back to animals on a large scale is particularly difficult to achieve where experience with tractors has been widespread). The focus of new stall-feeding efforts might therefore best be directed towards new settlement areas under the Mahaweli and other projects.

Current stall-feeding systems at Kaudulla rely on cut-grass feeding, and achieve use-levels per animal, and animal sizes, comparable with open grazing. The introduction of improved feeds would increase both the power output per animal and the length of time over which work can be sustained. The potential for growing improved feed crops clearly exists on highland allotments, most of which are grossly underutilised. Similarly, we have observed in Polonnaruwa that potentially valuable rice bran is frequently sold for as little as Rs.5/ hundred-weight or put to low-productivity use as a fuel in parboiling.

Additionally, with stall-feeding the potential for use of by-products such as manure and milk is raised. Veterinary services are more

easily administered, the risk of disease appears to be reduced, and productive assets (in the form of draught animals) are more evenly spread among the community. Organisational problems in hiring out small numbers of animals are fewer than with the larger herds found under open grazing, and so the potential for raising overall use-levels is higher under small herd stall-feeding systems.

4. For the longer term, but requiring an early start, are policies designed to upgrade the genetic potential of the stock, and to raise overall populations. The selection of target characteristics in breeding programmes lies outside our field, but it is worth stressing that the introduction of larger animals will only succeed if adequate feeding systems can first be developed. The feeding issue must therefore be a prime focus of attention. As a starting point, the respective influences of nutritional and genetic factors on stamina and performance might be analysed through the use of experimental equipment such as that developed by Ilangatileke at Peradeniya (pers. comm.)

5. Finally, we must stress that buffalo development strategies should not be formulated in isolation from the potential offered by other types of animal draught. Bullocks, for example, are a dual-purpose draught animal (haulage and field work) and can achieve higher work output over longer periods than buffalo. They also require more careful husbandry and feeding. Whilst their potential has been widely exploited in the Jaffna area, their agricultural use in other parts of the country is not common. Would the potential for wider use either alongside or instead of buffalo development merit consideration? Or are the barriers (possibly cultural in origin) to such strategy too formidable? We feel that they should at least be considered as an option before buffalo development strategies defined.

In conclusion, tractors have historically gained ground through a wide network of subsidies, many of which have continued to exist untill very recently. A successful re-assertion of animal draught will depend to a large degree on a widening of the gap between current market costs of ploughing under the two

systems. Our evidence suggests that animal hire charges tend to follow the upward trend in tractor hire prices, and so escalating fuel costs alone are unlikely to widen this gap for the farmer who has to hire in either power type. The widening cost advantage would seem to lie primarily with those who can own animals, and this suggests that the thrust of policy should be towards more widespread ownership.

APPENDIX

Attachment 1.

HOURLY OPERATING COSTS OF FOUR-WHEEL TRACTOR

		Financial Rs./hr.	Economic Rs./hr.
A.	**4-WHEEL TRACTOR**		
1.	Annual capital charge[b]	42.28	30.92
2.	Repairs and maintenance[c]	24.70	24.70
3.	Fuel (1.24 gall/hr.)[d]	26.04	31.00
4.	Lubricants (0.2 x fuel)	5.21	6.20
5.	Housing, tax, licensing and insurance[e]	9.50	9.50
		107.73	102.32
B.	**IMPLEMENTS** (9 tine-tiller and cage wheels)		
1.	Annual capital charge[f]	6.12	4.47
2.	Repairs and maintenance[g]	3.57	3.57
	Sub total	9.69	8.04
C.	**TOTAL OPERATING COSTS**		
1.	4-wheel tractor	107.73	102.32
2.	Implements	9.69	8.04
3.	Operator payments	4.00	4.00
	Total per hour	Rs.121.42	114.36
	Total per acre (at.4 hours/acre)[h]	Rs.485.68	457.44 / 457.44

Attachment 2.

HOURLY OPERATING COSTS OF TWO-WHEEL TRACTOR

	Financial Rs./hr.	Economic Rs./hr.
A. 2-WHEEL TRACTOR		
1. Annual capital charge[b]	9.59	7.90
2. Repairs snd maintenance[c]	6.60	6.60
3. Fuel (0.185 gall/hr)[d]	3.88	4.63
4. Lubricants (0.2 x fuel)	0.78	0.93
5. Housing, tax, licensing, and insurance[e]	1.50	1.50
Sub total	22.35	21.56
B. IMPLEMENTS (rotavator and mud wheels)		
1. Annual capital charge[f]	7.16	5.91
2. Repairs and maintenance[g]	4.92	4.92
	12.08	10.83
C. TOTAL OPERATING COSTS		
1. 2-wheel tractor	22.35	21.56
2. Implements	12.08	10.83
3. Operator payments	3.00	3.00
Total per hour	Rs.37.43	35.39
Total per acre (at 8 hours/acre)[h]	Rs.299.44	283.12

Attachment 3.

NOTES ON ASSUMPTIONS USED IN TRACTOR OPERATING COSTS

(a) Since the present exchange rate (US $ 1=Rs.18) reflects the market value of the Rupee, no shadow rate is currently used in project appraisal studies (Central Bank).

(b) The animal capital charge (A), which incorporates values for the opportunity cost of capital, is:

$$A = \frac{P \times r}{N\left(1 - \frac{1}{(1+r)^n}\right)}$$

where:

(i) P is purchase price of a new tractor (Rs.190000 for a 47 H.P. 4 w.t. and Rs.24000 for a 7 H.P.2 w.t.)

(ii) r is rate of interest.

17% (F) is the current commercial bank rate for loans of less than Rs.100000. In certain project areas the interest rate on tractor loans varies from 12% to 16%.

10% (E) is the minimum internal rate of return used in some project appraisal studies.

(iii) n is the expected working life of the tractor in years (10 years for 4 w.t., 5 years for 2 w.t.)

(iv) N is annual usage of tractor in hours (1000 hours for 4 w.t., 800 hours for 2 w.t.).

(c) $\frac{R/M \times P}{\text{Total working life (hours)}}$

where R/M is the repair and maintenance factor (1.3 for 4.w.t and 1.1 for 2 w.t.).

(d) The current pump price of diesel (F) is Rs.21/gall. Since the estimated subsidy is Rs.4/gall (Ceylon Petroleum Corporation) the shadow price of diesel is assessed as Rs.25/gall. (E).

Fuel consumptions is based on the formula 0.12 litres/horsepower/hour for land preparation (FAO, 1980).

(e) $\frac{0.05 \times P}{\text{Annual usage (hrs.)}}$

(f) Based on the formula in (b) above:

(i) Purchase price of locally manufactured tine tiller and cage wheels is Rs.11000 for 4 w.t. (n = 10 years; N = 400 hours/year).

(ii) Purchase price of rotavator and mud wheels is Rs.6000 for 2 w.t. (n = 5 years, N = 268 hours/year).

(g) From (c) and (f.ii) above.

(h) (i) 4 hrs/acre for first and second mudland preparation. This compares with 5.1 hrs/acre for Anuradhapura District and 4.3 hrs hrs/acre for Mannar District recorded by the Department of Agriculture for two mudland (irrigated) preparations during Maha 1979/80 (Cost of Cultivation of Agricultural Economics, Farm Management and Statistics, 1979).

(ii) 8 hrs/acre for first and second mudland preparation, compared with 8.4 hrs for Polonnaruwa District by Department of Agriculture during Maha 1979/80.

In addition:

1. Threshing performance rate for 4 w.t. is 2 hrs/acre, with fuel consumption rate reduced to 0.88 gall/hr.

2. A note of caution - the appended tractor operating costs are based on current(May 1981) prices. Since the majority of 4 w.t. in the country are at least 4 years old the average level of operating costs, strongly affected by the purchase price, are considerably reduced. For instance, the present financial cost of operating a 4 w.t. bought new in 1977 for Rs.110000 and implements for Rs.6400 is calculated as Rs.84.87 per hour, or Rs.339.48 per acre.

Attachment 4.

DAILY OPERATING COSTS OF BUFFALO PAIR

		Financial Rs./day	Economic Rs./day
A	**BUFFALO PAIR**		
1.	Annual capital charge[a]	7.24	5.71
2.	Adult mortality loss[b]	1.52	1.52
	less calf value[c]	-1.62	-1.62
3.	Feed[d]	0.00	0.00
4.	Veterinary charges[e]	0.00	0.00
5.	Housing, licence and insurance	0.00	0.00
	Sub total	7.14	5.61
B.	**EQUIPMENT** (yoke, harness and country plough)		
1.	Annual capital charge[f]	0.89	0.70
2.	Repairs and maintenance[g]	0.56	0.56
	Sub total	1.45	1.26
C.	**LABOUR**		
1.	Herd labour[b]	1.08	0.54
2.	Driver/operator charges[i]	20.00	20.00
	Sub total	21.08	20.54
D.	**TOTAL OPERATING COSTS**		
	A + B + C (per day)	Rs. 29.67	27.41
	Total per acre:[i] at 0.3 acres/day	Rs. 98.90	91.37
	at 0.125 acre/day	Rs. 237.36	219.28

Attachment 5.

NOTES ON ASSUMPTIONS USED IN BUFFALO OPERATING COSTS.

(a) Annual capital charge (A)

$$= \frac{P \times r}{N \left(1 - \frac{1}{(1 + r)^n} \right)}$$

Where:

(i) P Rs.2030, the purchase price of a 4-year old buffalo pair (270 kg. cow, 310 kg bull at Rs.3.5/kg).

(ii) r (rate of interest) is 17% (F) and 10% (E).

(iii) n (expected working life of buffalo pair) = 8 years

(iv) N usage per year=333 hrs (FAO, 1980) or 66.6 days (at 5 hrs/day).

The slaughter value of the buffalo pair at the end of its working life is considered a benefit and is excluded as a cost of operation.

(b) Adult mortality loss is 0.05 P ÷ 66.6 days.

(c) Value of calf production (55% natality - 20% mortality, 70 k.g. calf at Rs.3.5/k.g.) = $\frac{\text{Rs.107.80}}{\text{Annual usage (days)}}$

(d) In most of the Dry Zone buffaloes are freely grazed. Where competition for grazing land exists an economic cost of feed will arise.

(e) Veterinary charges are generally negligible (See Table 18)

(f) Based on (a) above.

P (Yoke, harness and country plough) = Rs.250
n = 8 years; N=66.6 days.

(g) Repair and maintenance factor = 1.0 of purchase price (weighted for distribution of equipment usage between ploughing and threshing).

(h) Herdsman charges when animals not working = 2 adults + 0.55 calf = 2.55 x Rs.2 x 10 months = Rs.51.

Shadow charges for labour (E) are 50% of financial costs.

(i) This includes meals and other payments in kind.

(j) Parker, R.N. (1978).

Threshing rates are estimated at 0.25 acres per 5 hour day for a buffalo pair.

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