

DRAUGHT POWER FOR SMALL FARMERS: A CRITIQUE OF PLANNING METHODOLOGIES IN SRI LANKA

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Introduction

Fundamental theoretical considerations in the choice of production technique have been summarised by Sen (1960). In numerous other writings, a wealth of theoretical and empirical evidence has been amassed on issues central to the role of policy initiatives in the choice of technique; these issues include the nature and significance of market imperfections, the appropriate orientation of economic development policies under alternative political philosophies and resource endowments, and the scope for policy initiatives to modify or replace market forces in achieving social objectives under various scenarios. For the present discussion it is pertinent to record the several features of small farm draught power which in many developing countries, Sri Lanka included, would result in socially suboptimal resource allocation patterns if the supply and use of draught power were left to market forces alone :

First, some types of draught power require substantial commitment of foreign exchange resources, and the markets for foreign exchange, with narrow-based export-earning sectors and the current plethora of concessionary international funding schemes, are notoriously imperfect. Where such funds are limited and are the subject of competing investment opportunities and development strategies, it becomes necessary for a planned allocation of foreign exchange to be determined either through, or instead of, the market mechanism.

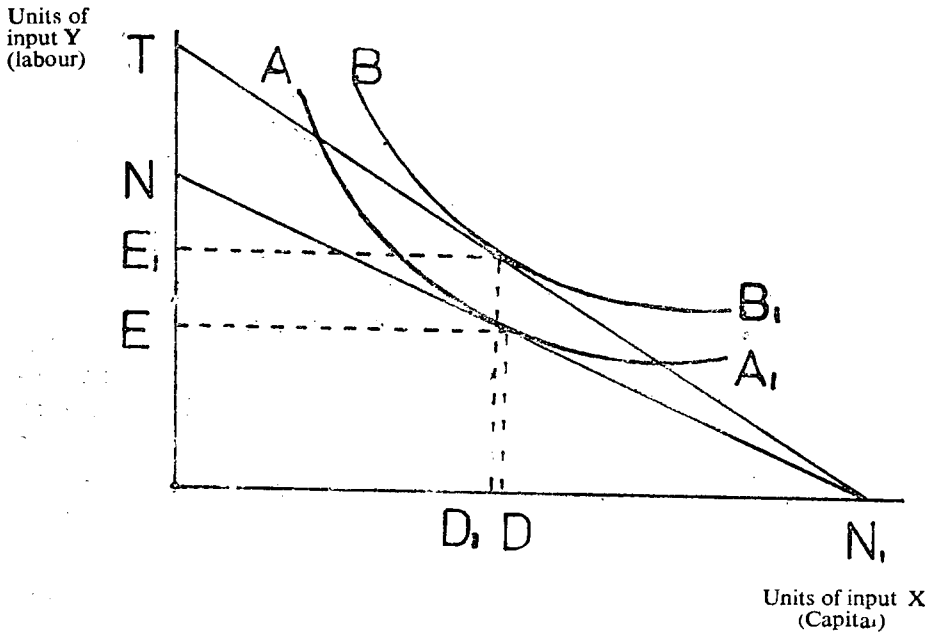
Second, where draught power use-patterns involve the commitment of other resources whose social value is not reflected in market prices, policy initiatives may be required to ensure a pattern of resource-use which reflects social costs and returns to such resources, though market forces might dictate otherwise.

For Sri Lanka, two resources whose social values differ from their market prices are strongly related to the type and quantity of power use: first, unskilled labour may have a social cost lower than its market price, and so investment in tractors may displace more labour than would be desirable at social prices. The second resource is irrigation water which, in practice, is issued free of charge to farmers in spite of its high social value. The social cost of using such water in pre-wetting the soil for easier land preparation is likely to be far higher than the private cost perceived by

individual farmers, even if we accept that the farmer attaches a positive opportunity cost to such water in terms of, for instance, reduced scope for a second season's cropping.

Such discrepancies between the impact of market and social values on the choice of technique can be illustrated in elementary economic theory : given an isoproduct curve ($A-A_1$) which illustrates the feasible combinations of inputs X and Y to produce a pre-specified level of output, L, in an assumed two-input production technique, the introduction of isocost curves (e.g. $N-N^1$) will

Figure 1: Choice of Technique in a Hypothetical Two-input Situation



illustrate different combinations of the two inputs that can be purchased, at fixed unit prices, for a given sum of money. The point of tangency between the isocost line equivalent to this ceiling and the highest feasible isoproduct curve indicates the least cost combination of the two inputs for which output L can be achieved : here, D units of X and E of Y. Clearly, taking input Y to represent labour and X as capital, if we postulate a shadow price of $P-1$ per unit of labour as against a market price of P it will be possible to purchase additional units of labour from the available funds, and a new least cost-combination of X and Y will result

($T-N_1$). This will be both tangential to a higher isoproduct curve ($B-B_1$) and will imply a relatively higher proportion of labour in the least-cost combination of inputs (E_1).

Similar results could be obtained in a consideration of our second example, irrigation water, whose opportunity cost to the farmer is likely to be much lower than its shadow price (see below). Additionally, the market-determined allocation of resources may produce effects which, while unacceptable within the social and political framework, are not amenable to conventional shadow pricing. One such effect associated with tractorisation in many parts of the world is the emergence of inegalitarian distributions of income and wealth (Mettrick *et al*, 1976). Accordingly, this too requires the attention of policy-makers in Sri Lanka.

To establish a case for government intervention in the various farm power markets in order to bring resource allocation patterns determined by market forces more closely into line with social cost-benefit optima is simple enough. What is more difficult is to ensure that such intervention is based on economically rational and consistent methodologies; if it is not, intervention may fail to realise the anticipated results, and the outcome may perhaps be inferior to what could result from the interplay of market forces alone.

The present discussion therefore is substantially a critique of current methodologies of farm power planning. It attempts to demonstrate, at the simplest level, the sensitivity of conventional analysis to certain key, but not easily quantified, assumptions within the existing methodological framework. It leads to a re-definition of the assumptions along what appear to be more realistic lines, and the conclusions are very different from those currently put forward for policy purposes. Further, it is suggested that the conventional methodological framework, relying on rigid technical coefficients, is lacking in sound economic principles and is so restrictive as to be fundamentally misleading. Proposals for a revised framework to take economic forces more adequately into account are made.

Current Methodologies in Policy Formulation

First we present current technologically-based methods of deciding whether the farm power stock is adequate in size and composition. To illustrate methodological shortcomings we present a critique of a recent FAO study to identify investment needs in farm power for the 1980s in Sri Lanka. Second, drawing on data and arguments presented in a current ARTI/ Reading University study on farm power we widen the discussion to include an array of economic considerations within the prevailing social and political framework. Our analysis of these leads to recommendations on how the decision making process might be improved.

(a) *Technologically - Based Methodologies*

Much of the discussion of farm power requirements for small holders has centred on the question of whether the stock of power is adequate to meet the requirements of the farming system. Two broad approaches have been taken. First, at the simplest level, casual observations of delayed and staggered land preparation have been translated directly into suggestions that the farm power stock is inadequate in overall capacity and/or in composition. This approach is deficient insofar as it implicitly assumes constant power use-efficiency levels, for which there are no *a priori* reasons. In fact, manipulation of the markets for power time and power stock may result in desirable increases in levels of use-efficiency.

Whilst, in a search for rigorous decision-taking methodologies, this approach must be dismissed as too crude, its current impact on decision-taking should not be underestimated: where land preparation is late or staggered, local-level officials are quick to seize on farm power shortages as an easily identifiable potential cause, and this notion gains credibility more through frequent repetition than through any rigorous evidence of causal links. The notion also finds ready acceptance in aid-donor countries with large tractor industries.

Second, a more "macro" approach to the relationship between agricultural acreages and the farm power stock attempts to estimate the total size of the draught animal and tractor stock, in order to arrive at the numbers available for farm work. This estimate makes allowance for the numbers broken down or fully employed for non-agricultural purposes. The use of selected performance rates then permits the potential work output of this stock to be compared with the available farming acreage. The potential to plough *more* than the available acreage indicates a *surplus* of farm power, and vice versa. This method has been used in many countries and formed the basis of a recent enquiry in Sri Lanka by the FAO to estimate future power requirements. The report of this enquiry will thus form the basis for future investment decisions in farm power.

The method relies on a number of assumptions, and exhibits extreme sensitivity to some of them. Let us consider the necessary complex of data and assumptions on which the method is based:—

- (i) Assumptions about the size of the farm power stock: Whilst data are available for the import and registration of tractors, many tractors (especially 2-wheelers) are unregistered; there is no unequivocal method of accounting for tractors which are irreparably broken down, permanently withdrawn from the small-farm hire market, or, because of their

precarious mechanical condition, reserved for such light agricultural operations as threshing. The only (highly imperfect) tractor population data on which to base planning are the Seasonal Reports of the Assistant Directors of Agriculture, and the (now outdated) findings of the 1974 Tractor Survey.

For animal draught, the population data are even less reliable. At least two widely conflicting sources of data exist : the Department of Census and Statistics Census figures for 1962 and 1973 and the Annual Survey figures based on the Grama Sevakas' estimates. The former shows almost a 50 percent decline since 1962, the latter a more or less constant trend in buffalo populations.

- (ii) Assumptions about performance rates of individual power types, estimated from experimental or farm-level observations: Whilst the impact of varying implement types and soil conditions can be taken into account, the condition of implements, tractor tyres and so on is much less easy to quantify, but has a strong effect on the speed and quality of tillage. Their condition can safely be assumed to be lower on farmers' fields than in experimental work. Similarly, the size of buffalo may be smaller, and their condition poorer, than in experimental situations.
- (iii) The length of period available for land preparation: Though this is perhaps the least easily quantified assumption it is an essential one for estimating the tillage capacity of a given stock of power over time.

Two distinct factors are involved – first, the time necessary for an individual farmer to complete his land preparation sequence will depend on his soil and water conditions, the density of weed growth, and so on. It will also depend on such institutional factors as his access to inputs and credit, and on the structure and efficiency of the power hire-market. Second, in the overall time taken by a group of farmers it is predominantly these institutional factors that will come into play. The less flexible the power and credit markets, the greater will be the extent of staggering among farmers.

(b) *The FAO Technologically Based Plan*

The assumptions made by the recent FAO Report on Farm Power availability, and its conclusions, are presented in Table 1. The basic conclusion of the FAO is that there is a farm power deficit equivalent to that necessary for ploughing some 29 percent of the current aswedumised acreage.

This finding is the basis of a recommendation to make US \$ 27 million, available to Sri Lanka as loans partly for the purchase of additional tractors and expansion of the buffalo stock. We wish to demonstrate that it is extremely sensitive to key assumptions, and that there is wide scope for uncertainty and error in these.

Table 1 : Farm Power Deficit Estimated by FAO and Underlying Assumptions

<i>Assumptions :</i>	<i>4-wheel tractors</i>	<i>2-wheel tractors</i>	<i>Buffaloes</i>	<i>Hand cultivation</i>	<i>Total</i>
Total Population ..	9,500..	9,000..	364,996..	— ..	
Population available for agricultural use ..	6,840..	7,740..	73,000*	— ..	
Length of ploughing season (days)	32.5 ..	32.5 ..	32.0 ..	— ..	
Performance rates (acres/day) (full land preparation) ..	2.0 ..	0.67 ..	0.154 ..	— ..	
Calculated acreage capacity ..	444,600..	168,538..	360,000 ..	224,006..	1,197,144
Actual aswedumized acreage ..					1,685,600
Estimated farm power deficit (acres)					488,456

* buffalo pairs.

A re-examination of the available data by the ARTI/Reading University farm power study team suggests the following weaknesses in the FAO assumptions:

- (i) Buffalo population. —Recent evidence suggests that, of the two sets of data from which buffalo population can be estimated, the Annual Livestock Population Survey of the Department of Census and Statistics, based until recently on Grama Sevakas' estimates, is more accurate than projections from the 1973 Census base. Evidence includes survey conducted by the Department of Animal Production and Health within a number of Agrarian Service Centre areas, and National Livestock Development Board surveys in Kurunegala. If the Annual Survey figures were to be adopted instead of projections from Census data, the buffalo population should be taken as 843,700 instead of 364,996 giving an effective agricultural work-force of 168,740 pairs. At 0.154 acres/day, this would give a seasonal tillage capacity of 831,551 acres instead of the 360,000 estimated by FAO, an increase of almost half-a-million acres, and in itself almost adequate to fill the farm power "gap" on an aggregate national basis, but with possible regional imbalances.
- (ii) Performance rates.—The assumed buffalo performance of 0.154 acres/day appears to be an underestimate. Whilst it may be an appropriate performance indicator for systems found in parts of the Wet and Intermediate Zones involving trampling or "mudding" of the soil, a more realistic estimate for their use with ploughs as is common in the Dry Zone, might be the 0.30 acres/day suggested by Parker (1978).

Using the FAO buffalo population estimates, the (admittedly extreme) application of modified performance rate assumption alone would add 340,800 acres to the buffalo tillage capacity. When combined with revised population figures, the increased tillage potential is some 1,259,904 acres.

Other assumptions might also be challenged, but it should already be abundantly clear that these two revisions alone would be sufficient to transform a claimed 488,456 equivalent acres of farm power deficit into an apparent surplus equivalent to 1,259,904 acres. In other words, at one extreme of the assumption spectrum, is a 29 percent farm power deficit, whilst at the other, there is a 46 percent surplus. It is not, however, necessary to press for adoption of one extreme set of assumptions instead of the other; even a "middle road" through these uncertain data suggests that the basic economic and technical assumptions underlying the recommended investment of US \$ 27 million are of dubious validity. Our argument suggests that even at the time of preparation of the FAO Report it should have been possible to adopt more realistic assumptions in the direction suggested, which would have prevented fears of a farm power gap at the overall national level, and might, instead, have encouraged policies directed towards more efficient use of the existing farm power stock.

(c) *New Data and Revised Methodologies*

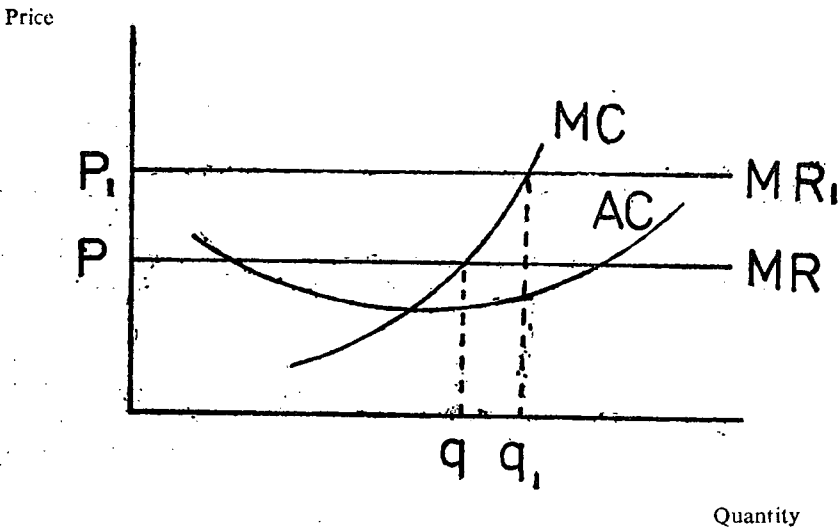
Methodologies concerned with attempts to establish whether a farm power gap exists ignore many conceptual problems. Fundamentally, they attempt to translate into technological terms what is basically an *economic* question. They suggest that there is a ceiling on farm power availability and that any requirement above this upper limit will remain inadequately satisfied, so that potentially cultivable land is tilled either late or not at all.

We now wish to consider the significance of these economic relationships, at two broad levels: first, we outline the economics of farm power use within the context of simple microeconomic theory; subsequently, we broaden the discussion to embrace less easily quantified, but nonetheless important, economic and social influences.

- (i) The theory of the firm postulates that a producer will use additional units of input up to a point at which the anticipated return from the additional unit (i.e. marginal revenue) no longer exceeds the cost of that additional unit (marginal cost).

For the individual farmer, this analysis easily relates to those inputs such as fertilizer or insecticide where small additions to the use-level are feasible. The theory can only be adequately interpreted for more "lumpy" inputs such as farm power in the context of demand and supply at the community level (although the simple theory of the firm will remain applicable at farm level to considerations of whether it will be profitable to perform an additional tillage operation). If, as the FAO study hypothesises, farm power is not available to farmers when they need it, and if farmers fear a lower output and profit due to increasing delays in cultivation, it is reasonable to expect the prices generally offered by farmers for power services to rise. Simple demand and supply theory predicts an increase in supply of power services in response to the higher price offered, which hardly needs to be illustrated here. From the point of view of the power owner, short run supply will increase until the marginal cost (MC) of supplying an additional unit of use is not exceeded by the marginal revenue obtainable from such additional use (MR) (see Fig.2). An increase in supply can be expected (q to q_1) from an increase in the price offered by farmers for hire services (which pushes MR up to MR_1).

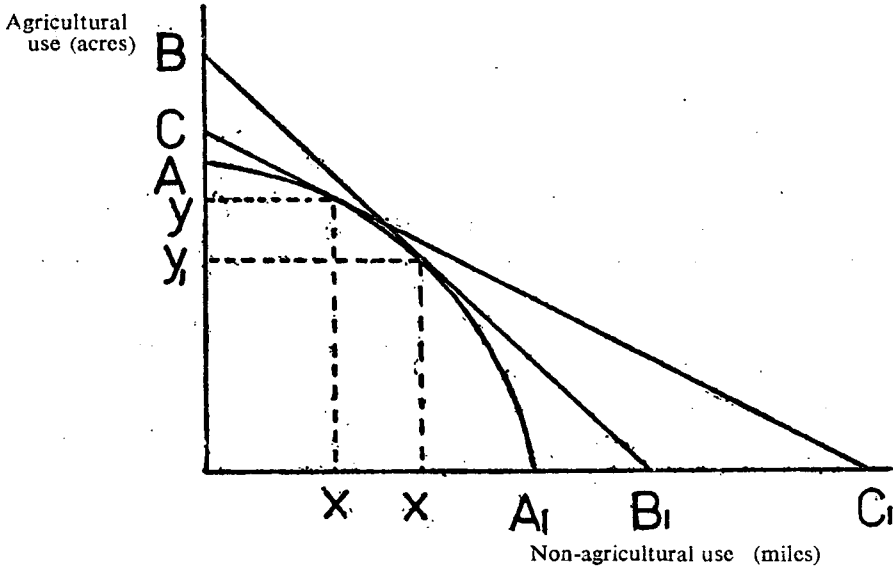
Figure 2: Price and Supply Relationships for Production Inputs



What our argument clearly suggests is that the concept of a "ceiling" of power availability is inapplicable. An increased price of hire services is likely to lead to an expansion in their supply, albeit possibly at a higher cost per unit.

A further theoretical possibility for increased supply of draught hire services in agriculture lies in a change in the balance between their use in agricultural and non-agricultural operations being currently undertaken even at peak agriculture seasons in some locations (Farrington *et al*, in press). This is illustrated in Fig. 3.

Figure 3: Resource Allocation Among Alternative Production Opportunities



$A-A_1$ is a production possibility curve for, say, tractors. It shows the various combinations of agricultural and non-agricultural use levels that can be supplied by alternative allocations of tractor time. Given the current prices per unit of agricultural (acre) and non-agricultural use (mile), it is possible to illustrate a series of iso-revenue lines, ($B-B_1$) showing different combinations of the two use-types which yield the same aggregate revenue. The inter-use allocation of tractor time which maximizes total revenue is given by the point on the production possibility curve ($A-A_1$) which lies on the highest attainable iso-revenue line, and will be at tangency to it. In our example this occurs at X units of non-agricultural uses. Let us examine the implications of a higher price per unit of one use-type such as would result from higher payments per acre for ploughing. This causes a shift in the slope of the iso-revenue lines, indicating that a higher output (i.e. mileage) in non-agricultural uses would now be necessary to achieve the new revenue levels obtainable from the same output (acres) in agricultural uses. The slope of $B-B_1$ thus becomes flatter—as for example in $C-C_1$. With the same production possibility curve, a higher total revenue-maximizing level of agricultural uses (Y_1) with corresponding reduced level of non-agricultural uses (X_1) is now indicated.

Applying our arguments more specifically to the market for draught hire, we could now state that the concept of a "ceiling" on the quantity of services which can be obtained from a capital good over a period of time is at odds with basic economic principles. In turn, this means that in the majority of circumstances higher use-levels can be obtained from fixed capital assets, though the cost of obtaining each additional unit of use (i.e. the marginal cost) may rise. Unless tractors are working at full capacity (i.e. for the sake of argument, 12 hours/day and 6 days/week in the short run, though our data below suggest far lower use-levels) there will be an economic trade-off in which increased use-levels can be obtained at (possibly, though not necessarily) higher unit cost. Upton (1976) has explicitly treated the relationship between the stock of tractors and flow of their use-services, and reaches broadly similar conclusions regarding the inappropriateness of basing planning exercises on the observed size and composition of the power stock supplemented by broad and inflexible assumptions regarding its use-level and composition.

Even if tractors were working at full capacity during the land preparation period, this would not necessarily mean that the proportion of their use-hours in agricultural activities had reached its limit: there is a trade-off between increased exploitation of one economic opportunity and revenue foregone through lower exploitation of another, and use-patterns will shift according to relative returns. Thus, if ploughing becomes a particularly profitable opportunity (as market forces suggest it would in times or areas of scarcity) then some reallocation of power time between farm and non-farm activities might be expected. Other possibilities deserve consideration: what might appear to be a surplus demand for power at a given quality and cost of land preparation may in part be satisfied by some lowering of quality, a speeding up of the operation, and consequent costs to the farmer in terms of reduced yield or increased manual or chemical inputs necessary to maintain yields. It is clearly unrealistic to suggest that the relationship between quality of land preparation and yield is an "all or nothing" one, in which no yield is obtained if land preparation does not reach the stipulated standard. Economic trade-offs are involved, and should be explicitly recognised in the planning process.

All this, however, suggests that *even* if the total use-hours obtainable from power is up against a ceiling there still remain ways in which economic forces might act to obtain at least some kind of power service to meet the surplus demand. The important outstanding issue is whether current farm power use-intensity is, in fact, subjected to a ceiling. Contrary to the FAO Report, recent data from the ARTI/Reading University Study suggest that this is far from being the case.

Table 2 : Average Use-hours/Week¹ for the Period 26.8.79 to 19.1.80 by Location, Power Type and Operation Category

Study Location	4-wheel tractors			2-wheel tractors			buffalo pair		
	Agriculture operations	Non Agriculture operations	All operations	Agriculture operations	Non Agriculture operations	All operations	Agriculture operations	Non Agriculture operations	All operations
Uda Walawe	4.7	9.8	14.5	5.9	7.4	13.3	6.8	—	6.8
Kaudulla	6.3	5.5	11.9	7.6	3.7	11.3	6.9	—	6.9
Padaviya	12.0	3.3	15.2	13.4	3.0	16.4	6.6	—	6.6

Source : Farrington *et al.*, (forthcoming), Table 21.

1. Chronological hours, not tractor-instrument records, per power unit. Power-use time does not include initial travelling time to and from the job, but does include time spent in travelling between fields and between farms for the same operation within the overall work period. For transport work, it includes the time spent by the power unit in queuing, loading and unloading, but not time spent travelling to/from the base before/after the job.
2. Agriculture operations are defined to include the transport of agriculture-related goods.

Individual entries may not tally because of rounding errors.

Table 2 summarises the hours worked per week by individual power types over the three study locations for the early part of the 1979–80 maha season. Over the 20-week period as a whole, which includes the maha land preparation during which the demand for power will be at its highest, tractor use-levels average some 11–16 hours/week, and buffaloes some 6–7 hours/week. During the brief peak period of maha land preparation, use-levels lie in the range 18–27 hours/week for tractors, and 17–22 hours/week for buffaloes. A variety of factors appears to have contributed to low power-use. Whilst these have not yet been fully analysed, preliminary indications are that a lax administration of irrigation water for pre-wetting the soil, coupled with the absence of penalties for those farmers whose cultivation is staggered beyond the stipulated seasonal limits, sets a psychological framework of much lower urgency than would exist within, for instance, rainfed farming systems. Within this framework the more conventionally acknowledged issues of unwillingness to work in heavy rain and breakdowns of long duration owing to the scarcity of spares make an additional contribution to low use intensity. Whilst the precise balance among these factors is not yet known, it is clear that many of them are amenable to amelioration though policy initiatives, and a resultant increased power use-efficiency can be anticipated. Additionally, at Uda Walawe and Kaudulla there is certainly also scope for shifting the relative proportions of 4 wheel tractor time in favour of agricultural operations, even at peak periods (Farrington *et al.*, in press Figs 4–9).

A brief note on structural imperfections in the farm power hire market would be appropriate at this point, since they have a bearing on the feasibility of attempts to increase farm power use-efficiency. These have already been touched upon in our main report (Farrington *et al.*, in press); to recap: much circumstantial evidence exists to suggest a degree of collusion among power owners in fixing hire charges and determining the quality of work. In particular, whilst many tractor owners appear to depreciate their capital assets over a much longer period than purely commercial considerations would dictate, and thus are satisfied to obtain low use-levels, market imperfections permit them to levy hire charges no lower than those required by commercially minded power owners who seek rapid returns to their capital assets which have relatively high use-levels but are depreciated over a shorter life. Lack of competition implies that the profits resulting from these rentals are high, as earlier empirical work by Carr (1975) and Harriss (1977) has suggested.

Part of this argument is admittedly conjectural: it gives rise to a set of hypotheses which can ultimately be tested against data not yet processed. But if the line of reasoning is broadly valid, there is reason to fear that structural imperfections in the power hire markets may impair the effectiveness of strategies designed to increase power use efficiency such as more stringent water control in land preparation and at the end of season and improved availability of spare parts and servicing facilities. Such strategies may have to be supplemented by essentially longer-term ones designed to make hire markets more competitive, such as the compulsory incorporation of a credit component in tractor purchase, which has to be repaid at predetermined (and manipulable) rates over the first few years of tractor life, and/or a policy initiative to spread power ownership in smaller units over a larger number of owners. Alternatively, some direct manipulation of the hire market such as that introduced at the Five Tanks (Russell, 1980—Personal Communication) in order to achieve rapid rainfed cultivation in Maha 1980-81, may be desirable.

(ii) The case we present above for the inclusion of elementary economic considerations in farm power planning can now be extended. In our introduction we suggested that the current values of certain inputs complementary to, or substitutable for, farm power perceived by farmers do not necessarily correspond with their social opportunity cost. The implications of such discrepancies, whilst of central importance to economically rational planning of farm power at the national level, are treated by the recent FAO study in a less than rigorous fashion. Let us consider these inputs in turn :

(a) Water—As we suggested above, there seems no particular justification for assessing farm power availability against the criterion of a 32- day land preparation period. The period is conventionally much longer and power

use intensity correspondingly lower than postulated. In most irrigated cultivation, particularly in the Dry Zone, delayed or staggered cultivation involves excess consumption of water for pre-wetting the soil. Whilst water consumption has a social cost which might profitably be reduced, any individual efforts by farmers to reduce its consumption by more timely and better synchronised ploughing do not yield benefits which can be reaped by individuals in proportion to their efforts. Moreover, any such benefits are obtainable only in the distant future—e.g. through irrigation of larger acreages in yala. What is needed is group action on a large scale (the group perhaps needing to correspond as a minimum with the area commanded by a main channel). The absence of such effective group pressure to date is likely to contribute strongly to a discrepancy between farmers' perceived valuation of water saving and its social opportunity cost.

Contrary to the common assumption (re-iterated in the FAO Report) that the most profitable course would be to prepare land in the shortest possible time, and thus use the minimum of stored water for pre-wetting, there is an economic interface between the benefit of water saving and the additional cost of obtaining more use from the existing capital stock (or, as currently proposed, making additions to the capital stock) which needs to be treated explicitly.

Even casual impressions of tank-based farming in the Dry Zone are sufficient to suggest that the wide range of existing power and water resource endowments will make it impossible for a single solution to be applied across the board. To take extreme cases: water will have a much higher social value in circumstances where reduced water consumption in land preparation can result in increased cropping intensity or an expansion of cultivated acreage (either at the site in question, or by canal or drainage flow, further downstream) than where such possibilities do not exist (e.g. at a coastal location where abundant water is available and all available land and cropping possibilities have been taken up). The socially optimal combinations of power and water use-levels will differ, in spite of the fact that farm power may have similar market and social values at each of these locations.

- (b) Labour—In spite of the substantial evidence of seasonally migrant flows of labour (e.g. Crooks and Ranbanda—forthcoming), it is reasonable to suppose that certain rigidities in the labour market might remain to make the market prices of labour spatially different at given times of season. Additionally, the availability of alternative work-opportunities will vary spatially and temporally, so that, in the absence of perfect labour mobility, the ratios of social to market values of labour will vary across the country and over time.

The economic interaction of power technologies and labour at the simplest level is confined to the social costs and benefits of job creation or destruction resulting from changes in the power mix. As we have outlined elsewhere (Farrington and Abeysekera, 1979), even this is a complex interaction: whilst it is generally recognised that increasing levels of mechanisation lead to a reduction in labour requirements on a per-acre basis it is not known whether the potential that tractors have for further job creation by expansion of the cultivated acreage or by increased cropping intensity is actually realised. Nor have attempts been made to measure whether the use of tractors releases small-farmer entrepreneurial resources whose re-deployment could lead to job creation.

Further complexity is added by including water in the power/labour interaction. A water saving resulting from more intensive use of power may permit job creation through changes in the crop mix, increases in cropping intensity or expansion of the cultivated area, yet such increases in power-use intensity, whether through raising the use-levels of the existing power stock or by adding to it, are clearly not cost-free. Optimal solutions will therefore be economically and not technically determined, and the resource-combinations they imply will vary temporally and spatially.

Superimposed on this complex of farm power, production, water, employment interactions are questions of wealth and income distribution. These are not concepts which can be applied independently of the socio-political context: what may be an acceptable distribution of income and wealth under one set of socio-political norms may be unacceptable under another. Some governments may emphasise the need to increase production through a system of private entrepreneurial initiatives and rewards; others may emphasise programmes of sharing the responsibilities and rewards of community-based production. Pragmatic incorporation of equity issues into economic planning thus requires an ability to identify "common ground" criteria acceptable to a wide range of political philosophies.

Whilst this is inevitably an arbitrary process, it is perhaps possible to suggest with reference to the medium-term planning of farm power in Sri Lanka that whilst rewards to the investment and entrepreneurship required by private acquisition and use of capital must be forthcoming, they should not be reaped at the expense of other members of the community. We accept that this criterion begs certain questions of definition, but would suggest that it permits preliminary weighing of the available evidence. Such evidence, although not yet fully analysed, suggests that 4 - wheel tractors constitute a technology particularly

favourable to the accumulation of productive resources which yield an income more than adequate to reward investment and initiative. Whilst, in principle, safeguards exist to prevent such accumulation at the expense of other members of the community, these are currently (and are likely to remain) inadequately enforced, so that exploitative relationships, at first potential, become real.

Detailed quantification of this relationship is impractical here; a central issue is the control of land, and our data suggest that whilst the acreage of land controlled by power owners (especially 4 w.t. owners) has increased markedly, that of non-owners has tended to remain constant or decrease. Similarly, examples of the exploitation of *bethma* cropping arrangements by tractor owners and of their acquisition of control over land at low rents in times of economic stringency in the broader farming community, have already been quoted (*Ceylon Daily News* 13-14/11/80).

Conclusions

The thrust of this paper has been to demonstrate that planning of farm power in Sri Lanka is necessary to adjust resource allocation patterns towards optima dictated by their social opportunity costs and returns, and away from those dictated by market prices, but that current methods of planning farm power for small-farm development are inadequate on several counts: first they are highly sensitive to a small number of key assumptions which are difficult to quantify. None of these sources of error is acknowledged in current planning exercises. More fundamentally, they present as static and technologically-determined relationships what are essentially economic interfaces. Thus, they are led to conclude that some ceiling of use-levels on the existing farm power stock has been reached, and that additional investment is therefore necessary. We demonstrate that even in the simplest of models, the level and composition of power use varies according to economic forces, and that empirical data reveal enough slack in current power use-patterns to suggest that some increase in use-intensity should be considered at least as one of several options in planning future power resources. Further, the broader issues of interrelationships among productive resources (*power, water, labour*) and their implication for the distribution of income and wealth are treated in only a rudimentary fashion (if at all) in current planning exercises, yet these are issues to which the selection of optimal power strategies is likely to be sensitive and some incorporation of them, even if imperfectly quantified, into future scenarios is essential.

We would suggest that a rigorous planning strategy of this type, whilst requiring some initial investments in methodological design and in data collection on e.g. local hydrological conditions and the labour and power markets, would in the long term generate substantial benefit in terms of farm power policies which would:

- (i) strike the optimum balance between increasing the use levels of the existing stock and replacement expansion strategies;
- (ii) develop such strategies within the framework of the social costs and benefits of alternative power types, attempting to move gradually towards the more economically attractive alternatives;
- (iii) assist in the design of farm power policies compatible with the broader social and political framework.

The design of such a strategy is the object of a current large-scale collaborative research programme between the Agrarian Research and Training Institute and the University of Reading.

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