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FARM POWER IN BANGLADESH

Volume 2

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FARM POWER IN BANGLADESH

VOLUME II

Part 1

Some Aspects of the Economics of Animal Power

by

H. Mettrick

Part 2

Mechanisation and Institutions in Noakhali

by

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PART 1

Some Aspects of the Economics of Animal Power

by

H. Mettrick

CHAPTER 1: INTRODUCTION

Whatever decisions are taken about the introduction of mechanical farm power into Bangladesh, there can be no doubt that animal draught will have an extremely important part to play for any future that can currently be foreseen. This part of the Reading University study on farm power in Bangladesh is devoted almost exclusively to the role of animal draught power.

It is very different in scope, style and content from the other two parts. Its author was resident in Bangladesh for relatively short periods and did not have the benefit of daily contacts with Bangladeshi farmers. What it seeks to do is to pick up some of the themes relating to animal draught - based principally on the same survey data - that the other two parts have been unable to cover in detail. It does not pretend to be a rounded monograph on animal draught power in Bangladesh. In particular, technical aspects relating to tillage techniques, implements, husbandry or diseases have been completely omitted. A particular omission is any consideration of minimum or zero tillage on which some work has been done at the Bangladesh Rice Research Institute and which remains an important field for further investigation.

The availability of draught power is the first topic to be considered. Chapter 2 begins by reviewing the existing livestock statistics for the country as a whole. It goes on to consider the distribution of animal draught power at both farm and village levels, based on the data collected in the survey. An analysis is made of the age-sex structure of the cattle herds in the villages studied and an explanation attempted of their top-heavy structure. The parameters of herd reproduction are examined and their implications for future draught power availability is considered. A deteriorating supply of animal draught for at least the next few years appears inevitable.

Chapter 3 is concerned with the demand for draught power. The indivisibility of draught power has an important bearing on this subject and two different concepts of indivisibility are examined. On the basis of one of these concepts - indivisibility in draught services rather than capital items - a demand function for draught power is derived. Both supply and demand are shown to be stepped functions. Taking into account the lumpy nature of the technology, the distribution of draught power, and the extent to which farmers' available power is adequate for their needs for the areas covered by the Survey are calculated.

A possible explanation for low herd productivity in Bangladesh is the use of cows, often in an advanced state of pregnancy, for draught purposes. The extent to which females are used for draught in each of the survey areas is set out in Chapter 4. Calving percentages are calculated for herds using their cows for draught, and those which do not. There is a considerable difference between the two.

The implications of the difference are examined in Chapter 5. First a model is set out which calculates the structure of a stable population herd necessary to provide one unit of ox power. This is then modified to cover the case where cows are used for draught. There is a trade-off between increasing the number of draught animals by using females and the loss in herd productivity as a result of the reduction in calving percentage. The opportunity cost in terms of lost milk production is also calculated. From the survey data, estimates are made of the type and quantity of feed given to each draught animal and also the cost of those items which were purchased. The opportunity cost of animal draught is thus calculated for both herds using females and those not using females, taking into account also the production of by-products such as milk and dung.

There is an important relationship between land tenure and draught power. In Bangladesh virtually all tenants are sharecroppers. There is great competition among potential tenants to be selected by landlords and the latter can pick those whom they consider to be the better farmers. The usual arrangement is that the 'tenant' provides labour and draught power and inputs and output are shared in equal parts by landlord and tenant. Those wishing to be tenants who own draught animals are clearly at an advantage. In order to understand the economics of this relationship, Chapter 6 reviews the theory of sharecropping and considers its relevance to the situation in Bangladesh. Empirical evidence from some of the survey areas is compared with that obtained by earlier researchers.

In the final chapter results are summarised and their implications explored.

CHAPTER 2: THE AVAILABILITY OF DRAUGHT ANIMALS

2.1: Livestock Statistics

There has been no census of livestock in Bangladesh since 1960. Estimates have been made more difficult by losses suffered as a result of the cyclone and tidal bore of November, 1970, and the War of Liberation when as much as 25% of the national herd could have been lost. There has been a range of estimates of the size of the national herd in recent years, varying from 17.9 million (IBRD, 1972) to 29 million (Odend'hal, 1978). However, a sample survey in 1978 gave a herd size of 23 million and this is consistent with the two tables below setting out changes over time in the size of the herd and herd structure in 1977.

TABLE 2.1: LIVESTOCK POPULATION IN BANGLADESH (Thousands)

	Cattle	Bullocks	Buffaloes
1960	19,200		500
1965	23,000	7,120	600
1970	25,000	7,590	800
1973	19,400		600
1974/5	20,100		650
1975/6	20,800		700
1976/7	21,500	7,805(1)	760

Source: Alauddin Ahmed (c.1978)

(1) From Table 2.2.

TABLE 2.2: ASSUMED CATTLE AND BUFFALO POPULATION STRUCTURE 1977

	Cattle		Buffaloes	
	Thousands	%	Thousands	%
Cows in milk (working)	669	3	8	1
Cows in milk	2,453	11	34	4
Cows, dry	2,230	10	111	13
Cows, working	2,676	12		
Breeding bulls	223	1	8	1
Bullocks, working	7,805	35	545	64
Bulls and cows and oxen (not working)(1)	669	3	17	2
Young stock up to 3 years, male	2,787	12.5	60	7
Young stock up to 3 years, female	2,787	12.5	68	8
TOTAL	22,300	100.0	851	100

Source: Government of Bangladesh and FAO/UNDP Mission (1977)

(1) The category for cattle is given in the original as "Bulls, cows and oxen (working)". It is assumed that this is a typing error.

Allauddin Ahmed (c.1978) estimates the total population of draught animals in 1976-77 as 12 million. On the basis of a pair to four cropped acres, he estimates a requirement of 20.5 million working animals by 1983, an increase of 70%. He claims that 25% of this can be met by annual growth, i.e. a rate of growth of more than 3% per annum. The Working Paper from which Table 2.2 is taken pointed out that demand depends on the area of cultivable land not on cropping intensity. Nonetheless, they base their estimate of the demand for draught power on the Directorate of Livestock Services' figure of one pair per four acres. They estimate the overall rates of growth of the cattle and buffalo herds to 1985 as 1%, but project the growth of the bullock population between 1980 and 1985 as 3%. This projection does not accord with the herd structure data collected in this present study.

2.2: Age-Sex Profiles

An age-sex profile for the ten villages together is shown in Figure 2.1, and for each one separately in Figure 2.2. In none of the villages does the herd structure suggest that the herds are capable of reproducing themselves. If these figures are at all representative of Bangladesh, what they imply is that there will be a declining availability of draught power for some considerable time to come.

A possible explanation for the shape of the profiles could be that farmers in the sample prefer to buy in their mature stock rather than breeding them themselves; the source could be other farmers within the village or the animals could have come from completely outside the village. It makes sense to have a stratified industry if there are other individuals or other areas with a comparative advantage in cattle breeding, which implies access to cheap feed and possibly also low opportunity cost labour for looking after the animals, e.g. child labour. An overwhelming proportion of mature stock have, in fact, been bought. However, Table 2.3 demonstrates that virtually all cattle were either bought or were born on the farm and hardly any were obtained by inheritance or as part of a dowry. Those that were born on the farm account for 25% of males and 45% of females, and 71% of males and 48% of females were purchased. If farmers have had to build up their herds themselves, rather than inheriting their livestock, one would expect to find the younger stock predominantly born on the farm and the old stock predominantly bought. Moreover, where herd sizes are very small and farmers are keeping their animals for specific purposes - oxen, cultivating cows, milk or breeding cows - there will tend to be very much more buying and selling than where herd sizes are larger and retained, say, as a store of wealth. Hence, the large proportion of bought animals cannot be taken as proof that the herd structures are unrepresentative.

There are, it is true, areas of Bangladesh where land is under less extreme pressure than elsewhere, and there are pockets of grazing available on less fertile land. However, these are very limited and are certainly not sufficient to support an inter-regional trade on any substantial scale. The major large-scale market is in slaughter-stock for the Id religious festival; in the sample villages 37 animals were recorded as being fattened for Id, most of them in the two Munshiganj villages which are relatively close to Dacca. We know that animals have been brought into Noakhali to replace stock lost in the 1970 cyclone and, apart from Bogra which has hardly any at all,

FIGURE 2.1: AGE AND SEX OF CATTLE IN ALL TEN VILLAGES

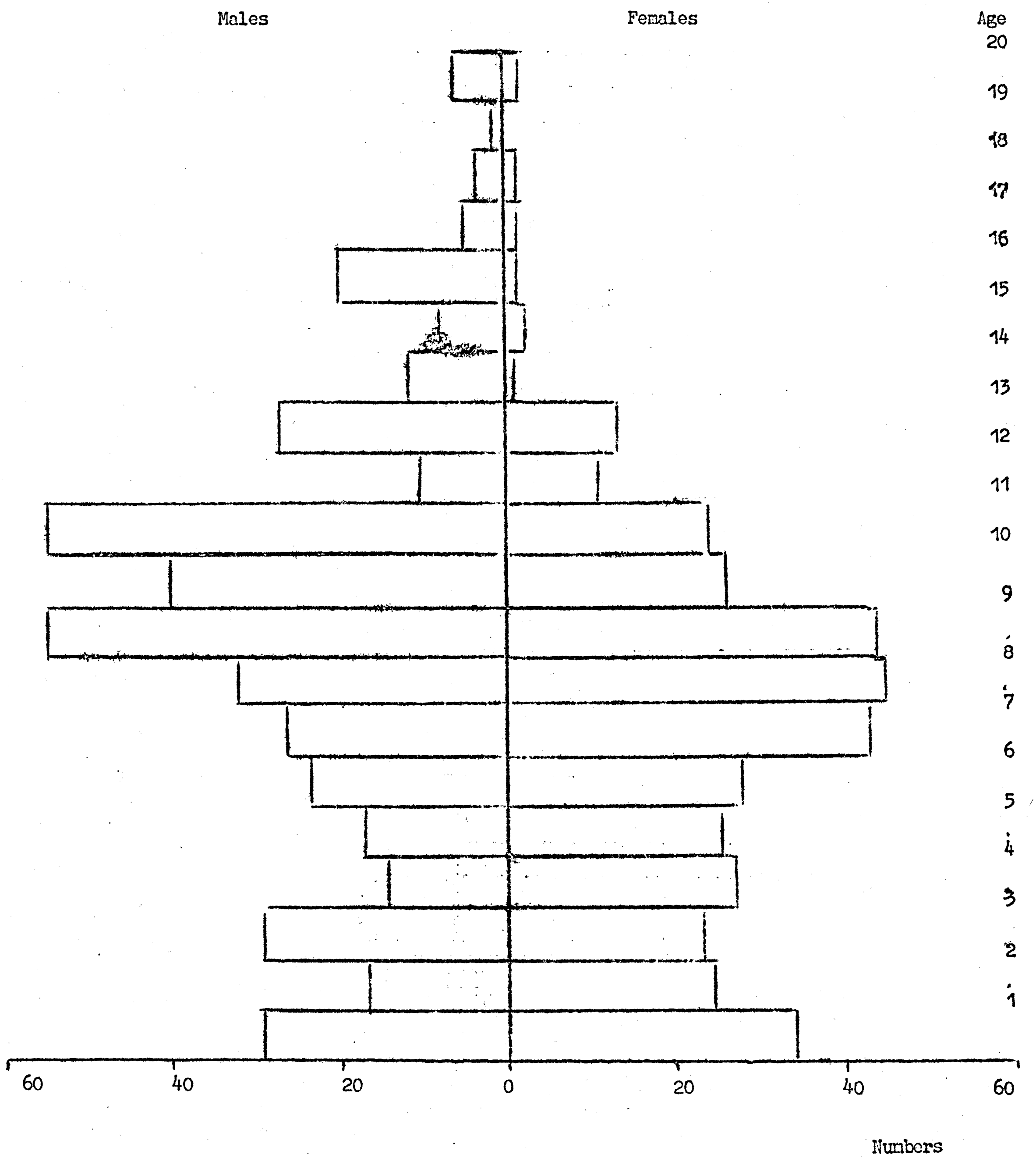
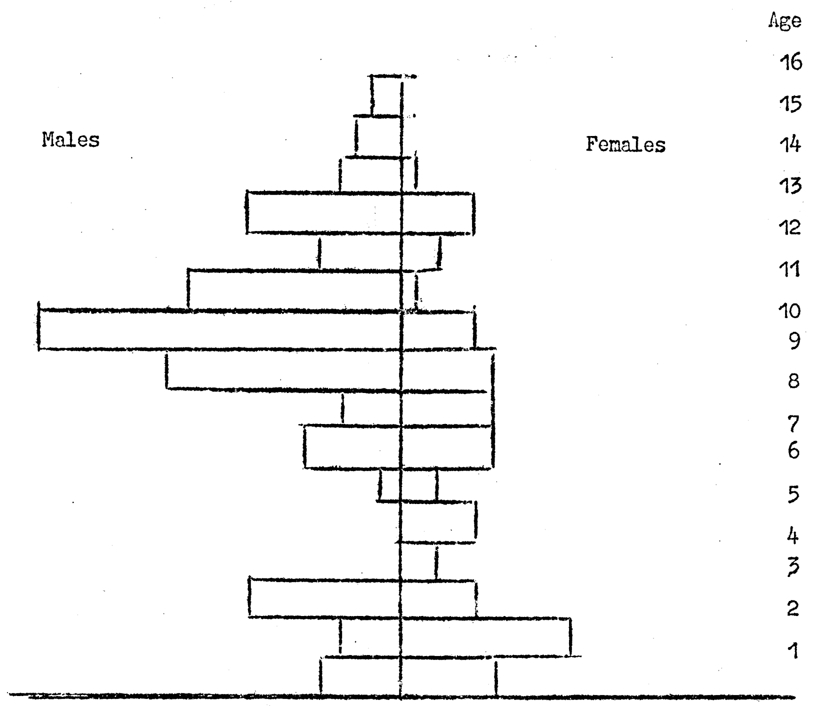


FIGURE 2.2

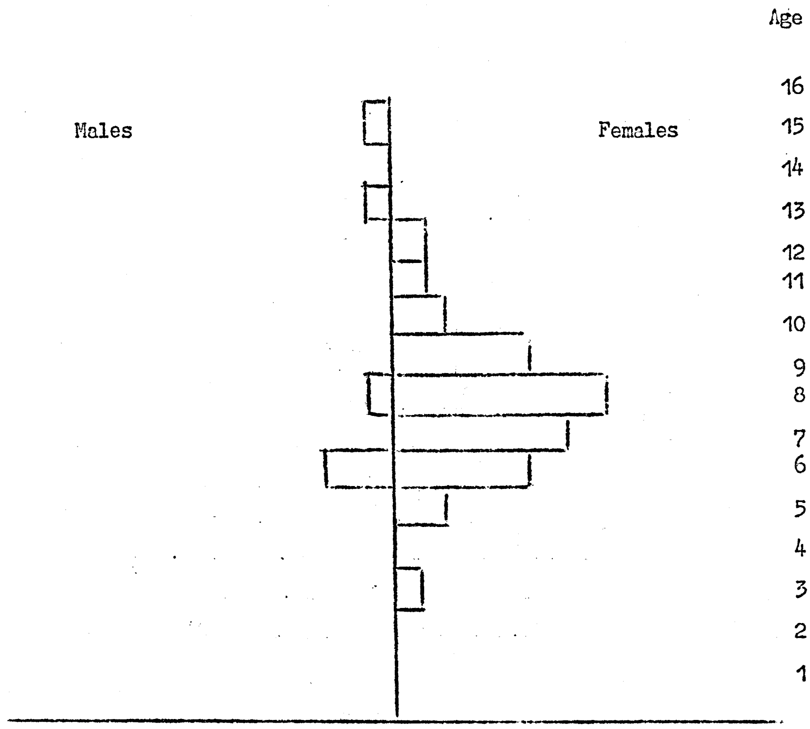
RANGPUR



COMILLA

FIGURE 2.2 (continued)

BOGRA



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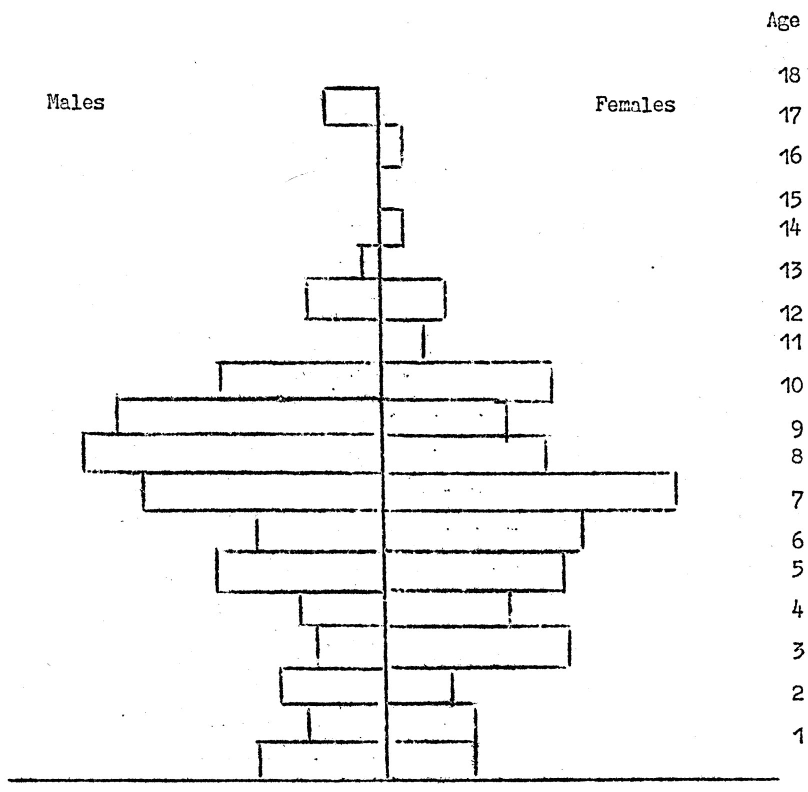
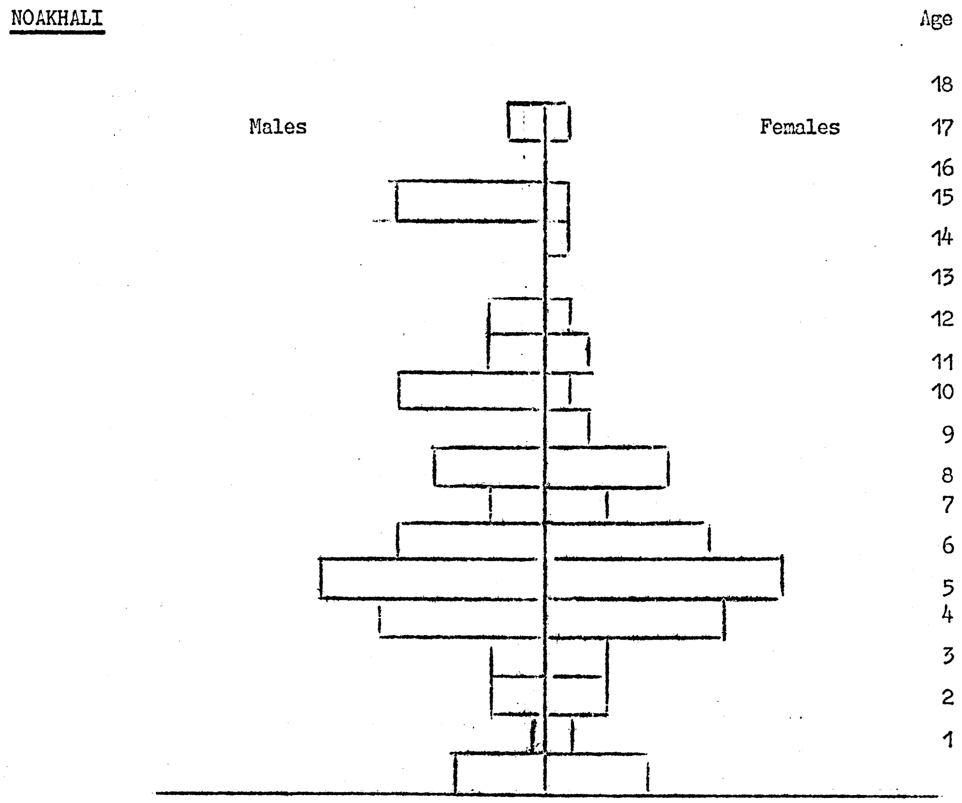
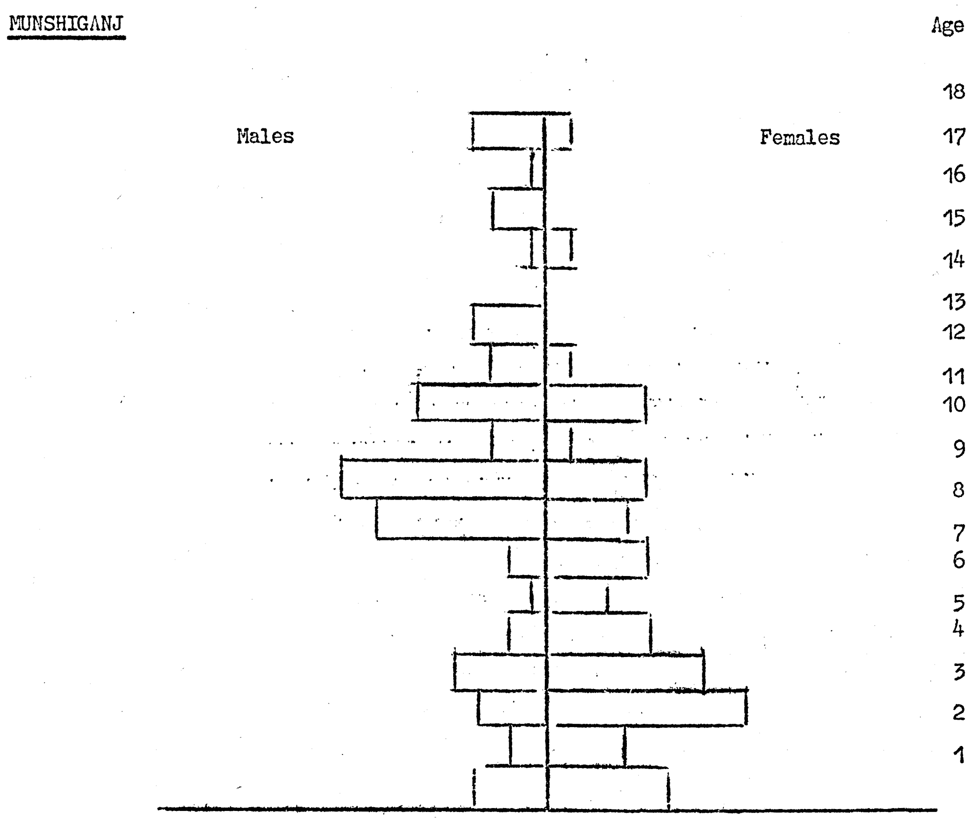


FIGURE 2.2 (Continued)





this is the only area which has more oxen in the 4-7 than in the 8-11 age group. It is clear that the Bogra village exports its males, but it too has a perverse profile on the female side. If the explanation is not importation of animals, then it would appear that we have been unlucky enough to pick a sample with every one of the ten villages a net importer.

TABLE 2.3: SOURCE OF CATTLE OWNED BY SEX AND VILLAGE

Cattle numbers

Village		1	2	3	4	5	6	7	8	9	10	Total
Born on farm	M	25	-	26	9	5	17	4	13	7	4	110
	F	42	2	33	11	4	35	5	22	10	11	175
Bought	M	68	6	26	36	35	19	28	29	33	35	315
	F	12	36	26	17	9	24	7	19	15	18	183
Adhi[(1)]	M	-	-	-	3	1	2	-	-	-	-	6
	F	-	1	-	-	2	-	-	1	2	-	6
Gift	M	-	-	1	-	1	1	-	-	1	-	4
	F	1	4	-	-	-	2	-	-	-	1	8
Inherited	M	-	-	2	1	1	1	-	-	-	-	5
	F	-	2	2	1	-	-	-	-	-	-	5
Dowry	M	-	-	-	1	-	-	-	-	-	-	5
	F	-	-	-	6	-	-	-	1	1	-	8
TOTAL	M	93	6	55	50	43	40	32	42	41	39	441
	F	55	45	61	35	15	61	12	43	28	30	385

(1) A system of cattle management similar to sharecropping.

If cattle breeders (and sellers) were resident in the same village, our sampling procedure would have excluded them if they cultivate no land, either because they sharecrop it all out or because they are landless. However, the latter would have no access to crop residues - which form the major part of the animals' diet - and the former would have access only if the share agreement stipulated division of the crop residues. Furthermore, the value of livestock is such that they represent an investment which is completely outside the scope of the landless. In any case, the sociological survey, which was a complete enumeration of the two Noakhali villages, failed to reveal a single household in either of these two categories who own cattle.

The particularly anomalous feature of the profiles is the comparatively large number of oxen over eight years of age and less than twelve. Over the sample as a whole there were 60% more in this group than in the four to eight year old category. Thus, even if we do have a sample with a propensity (as a group) to import draught animals, the draught population - particularly male, but to a lesser extent also female - is an old one. The median age for the male population lies between eight and nine years and for those of working age between nine and ten years. If these animals have been bought from elsewhere where are the complementary profiles? It is not easy to see where replacements will come from when these oxen finally succumb to old age.

TABLE 2.4: PROJECTIONS OF DRAUGHT POPULATION BASED ON SAMPLE HERD STRUCTURE

Projection 1	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Herd Size	7950	8006	8204	8153	8029	7904	7786	7708	7554	7516	7491
Breeding Females	1345	1353	1321	1277	1230	1208	1204	1180	1155	1152	1166
Replacement Females (4-5)	250	262	216	219	279	332	333	325	315	303	298
Draught Males	3450	3439	3247	3084	3042	3027	2985	3006	2942	2944	2921
Draught Females	1345	1353	1321	1277	1230	1208	1204	1180	1155	1152	1166
TOTAL DRAUGHT POPULATION	4795	4792	4568	4361	4272	4235	4189	4186	4097	4096	4087
Projection 2											
Herd Size	7950	7934	7944	7775	7545	7320	7091	6900	6625	6441	6369
Breeding Females	1345	1353	1321	1277	1230	1180	1149	1100	1052	1025	1014
Replacement Females (4-5)	250	262	216	219	279	275	277	270	262	253	243
Draught Males	3450	3439	3247	3084	2980	2909	2815	2787	2679	2630	2631
Draught Females	1345	1353	1321	1277	1230	1180	1149	1100	1052	1025	1014
TOTAL DRAUGHT POPULATION	4795	4792	4568	4361	4210	4089	3964	3887	3731	3655	3645

Calving Percentages:

Projection 1: Breeding cows 35% Cultivating cows 25% Cultivating cows 50% of total;
Projection 2: Breeding cows 30% Cultivating cows 20% Cultivating cows 50% of total.

The aggregate profile (Figure 2.1) suggests a declining calf crop beginning in 1970 or 1971, culminating in a minimum about 1975 and a subsequent recovery. It is perhaps not necessary to look further than the sequence of catastrophic events which have already been remarked on; cyclone, War of Independence and finally drought and famine. If these resulted in a disproportionate slaughter of young stock combined with a decline in fertility, the effect would be similar to that shown in the profiles. It is important to note that if this is the explanation for the shape of these profiles, the full impact on the draught population has not yet been fully felt, owing to the relatively old age both of the draught population and also the breeding herd.

2.3: Herd Projections

The point is best illustrated by considering projections of the herd based on a variety of assumptions. These projections are not intended as accurate predictions of what the herd will be, but as an exploration of the dynamic implications of the structure of the herd. The starting herd structure is identical with that in Figure 2.1; no attempt has been made to smooth out the bumps. The following are assumed:-

1) The mortality of calves in their first year of life is 10%;
2) Subsequent mortality is 3%, except that
3) Mortality of males over 11 and females over 9 is 20%;
4) Mortality of males at 18 and females at 15 is 100%;
5) There are no slaughterings or sales out of the herd;
6) All males of three years and over are considered to be draught animals;
7) Half the female herd of four years and over is kept only for milking-breeding; the other half also cultivates. The two groups have different reproductive rates.

Projection 1 assumes calving percentages of 35% and 25% for milking-breeding cows and those which also cultivate, respectively, and projection 2 assumes 30% and 20%. These are set out in Table 2.4. All the figures have been multiplied by ten to reduce rounding errors.

These calving percentages are admittedly extremely low. They are based on the figures derived in Chapter 4 and set out in Table 4.3. Any higher calving percentages would not be consistent with the profiles in Figures 2.1 and 2.2. It might be remarked that the calf mortality figure is also a low one. FAO have suggested that the mortality of calves in Bangladesh in their first year of life is as high as 50%. With a 50% calf mortality the calving percentage has to be increased to 54% in order for there to be the same number of calves surviving their first year as there would be with a 30% calving rate and 10% mortality. We could, therefore, assume a 59% calving rate for non-cultivating females and 49% for draught females, plus a 50% calf mortality without changing any of the figures in projection 1.

A number of features of the model may be pointed out. First, whatever rates of reproduction are assumed, they only affect the adult herd in year 4 in the case of males and year 5 in the case of females. During this period, because of the age structure of the herd, both adult males and adult females have been dying off more quickly than they can be replaced. Although on Projection 1 replacement females are greater in number than in any of the previous five years they continue to decline after year 5, because the cow herd producing them has been declining. When the up-turn in the cow herd does come, it is because the bulge in the cow herd has passed and mortality is decreasing faster than the decline in the number of replacements. Thus a cycle is set in motion with a new bulge passing through the cow herd. It will depend on the calving percentages assumed and their relation to assumed mortalities as to whether the movement is cyclical about an increasing, steady or decreasing trend.

2.4: Critical Calving Rate

The herd will be in decline if the calving rate is so low that the herd of breeding females cannot sustain itself. There will be a critical calving rate below which births are inadequate to compensate for deaths. This can easily be derived using the concepts and notation of Chapter 5. In that chapter a model is developed for calculating the cost of animal draught, both with and without the use of females. A stable herd size is assumed and any excess females are disposed of at birth.

Let

F_r = number of reproductive females in herd
F_b = number of females born each year
b = number of births per reproductive female
n = proportion of calves born each year which are male.

Then

$$F_b = F_r(1-n)b \qquad (1)$$

Let

S_1 = survival rate of immature females
Z_2 = sum of survival rates of adult females (i.e. adult females as a proportion of those reaching maturity each year)

Thus if

m = annual mortality of adult females

and

t = reproductive life (in years)

Then

$$Z_2 = (1-m)+(1-m)^2+\ldots\ldots+(1-m)^t$$

Let

p = proportion of female calves not disposed of at birth (see Chapter 5 for the significance of this)

Then

The number of females surviving to maturity is:

$F_b p S_1$

and from the definition of Z_2

$$F_r = F_b p S_1 Z_2 \qquad (2)$$

Substitute from (1) in (2)

$$F_r = F_r(1-n)bpS_1Z_2$$

i.e.
$$b = \frac{1}{(1-n)pS_1Z_2} \qquad (3)$$

The maximum value that p can take is 1.

Therefore, the minimum value that b can take and a stable population be maintained is:

$$\bar{b} = \frac{1}{(1-n)S_1Z_2} \qquad (4)$$

On the assumption above:

$$S_1 = 0.82$$
$$Z_2 = 8.85$$

If $n = 0.5$, then $\bar{b} = 27.5\%$.

Since the overall calving percentage in projection 1 is 30%, the herd should be able to sustain itself in the long-run on these assumptions. However, it is a very long time before a steady state is reached and, because of the anomalous profile from which we begin, the breeding herd continues to decline until year 9 and the total workforce does not begin to increase again until after this date. This is not inconsistent with an increasing total herd size during the first few years of the projection. If during the next few years a major catastrophe were to supervene, say a drought followed by a cyclone, or vice versa, the whole cycle would begin again before recovery is complete, and the equilibrium herd would be pushed even lower.

A number of features of the above discussion are worthy of comment. First, because of the great age to which the animals are kept, the cycle is a very long one. Secondly, because of the "mushroom"-shaped herd-profile, it is to be expected that even on reasonably optimistic assumptions about mortality and calving percentages, draught availability will continue to fall rather steeply. Thirdly, the use of females for draught reduces calving percentages quite sharply, indeed it is quite possible that it reduces the calving percentage below the critical value required for herd replacement. This topic is returned to in Chapter 5, where it is shown that farmers can increase their available draught resources by the use of females, but that in the long-run this is self-defeating if it lowers calving percentages below the critical value.

CHAPTER 3: THE DEMAND FOR DRAUGHT POWER

3.1: Two Concepts of Indivisibility

Much of the pressure for machine cultivation in Bangladesh, as in other parts of South Asia, is based on a belief that agriculture in these countries suffers from a shortage of draught power. Makhijani (1975) reports that shortages of power on Indian farms are frequent during the busy season, that is after the first rains, and gives as references Marvin Harris (1966), Gilbert Etienne (1968) and J. Mellor et al (1972). In his linear programming study of farm power in Pakistan, Finney (1972) showed a bullock constraint in April. In Sri Lanka there has long been a widespread belief that the Dry Zone, in particular, suffers from a serious shortage of draught power (Burch, 1979), and plans for the development of the Mahaweli Irrigation Scheme include the importation of a large number of tractors to meet this need. Farrington et al (1980) have pointed out that much of the existing fleet of tractors is under-utilised.

In Bangladesh the critical period is the turn-around between the aus and aman crops. In the absence of irrigation, the timing of the aus crop is entirely determined by the arrival of the pre-monsoon rains. Timeliness is of great importance in the establishment of transplanted aman if yields are not to suffer. Thus the farmer finds himself with a very short period in which to harvest the aus, prepare the land for the aman, and transplant the aman. At the same time there is pressure to thresh, dry and store the aus harvest to prevent it deteriorating in the monsoon weather. In addition, the advent of improved varieties of rice has extended the aus season by some three weeks, making the turn-around period even tighter. If a shortage of draught power manifests itself in Bangladesh agriculture, then it is likely to do so in these crucial few weeks.

The availability of animal draught power has already been discussed in Chapter 2. The adequacy of this supply can only be assessed in relation to demand. What is meant by a "shortage of draught power"? Is there a sense in which it can be said that there is a "draught power requirement"? Should the appropriate concept not be instead "marginal productivity of draught power"?

One of the important assumptions of competitive models in economics is that of indivisibility. It is clear that with farm power we have to deal with a lumpy rather than a divisible technology. There are, however, two concepts of divisibility which are relevant to an analysis of farm power and it is useful to distinguish between them. The first, more usual, notion is that of indivisibility in capital items. A farmer may buy one tractor or two, but not 1.37. He may own two or three draught animals, but not fractions of an animal. The second kind of lumpiness is where there is indivisibility in the services provided by a capital investment. Whereas investment in a tubewell is a lumpy investment, the service it provides - moving water from beneath the ground to the farmers' fields - is itself divisible. On the other hand the services provided by, for example, a tractor are not normally divisible. Each of these types of lumpiness is dealt with in turn.

3.2: Indivisibility of Capital Items

The response of communities to the problem posed by lumpiness of capital items has tended to be institutional, whereas that of policy-makers has been both institutional and technological. The technological solution has been to seek smaller machines more appropriate to the size of holdings. The institutional alternative is multi-farm use of machinery through private or public hire or through co-operative ownership.

It has been suggested that the optimum power rating of a tractor to be selected by a farmer-owner increases with:

"(1) increased land area handled (with added emphasis when timeliness is important);
(2) increased intensity of mechanical cultivation operation for each hectare;
(3) increased operator wage;
(4) increased economic importance of avoiding delays in scheduling;
(5) decreased cost per rated horsepower;
(6) decreased rates of fixed costs associated with tractor ownership".

(Chancellor, 1967, quoted by Hamid, 1979, p. 204).

On the basis of these variables Chancellor derived a formula for the optimum horsepower for a farm. Hamid used it to calculate the optimum size of tractor for Pakistan on the basis of a median farm size of 14.5 acres for farms in the category 7.5 to 50 acres. The value derived was 10 hp. He used this to argue the case for a "fractional technology" strategy for Pakistan.

A similar calculation for Bangladesh would inevitably produce a smaller figure. However, the formula assumes that the tractor will be used entirely on the owner's holding, i.e. that there will be no hiring. Thus the trade-off between economies of scale in the use of larger tractors and any disadvantages associated with multi-farm use is excluded from the calculation. The former is far from negligible (Pollard and Morris, 1978). A strategy cannot be designed on purely technical grounds. Technical and institutional factors are inter-twined.

It should be stressed that the calculation was only intended to give the optimum size of tractors and was not designed to provide a decision rule for choosing between tractors and animal draught. The social and institutional aspects of this choice are discussed in many places in the two volumes of this report.

The institutional response to the lumpiness of capital items is multi-farm use. In Bangladesh this has taken the form of extensive hiring of draught oxen, limited public hire of tractors and very limited private and co-operative hire of tractors and power tillers.

What is the economic mechanism whereby draught power is allocated between those who own it and those who need to hire? There is an opportunity cost to the owner in using his power source on his own

FIGURE 3.1

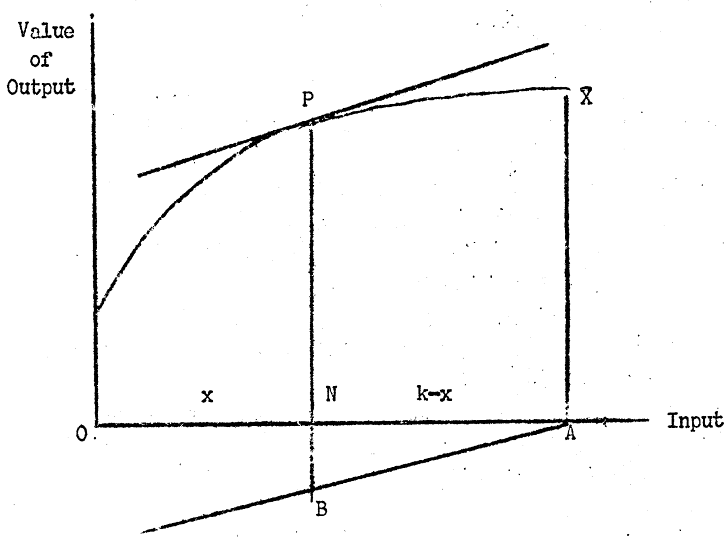
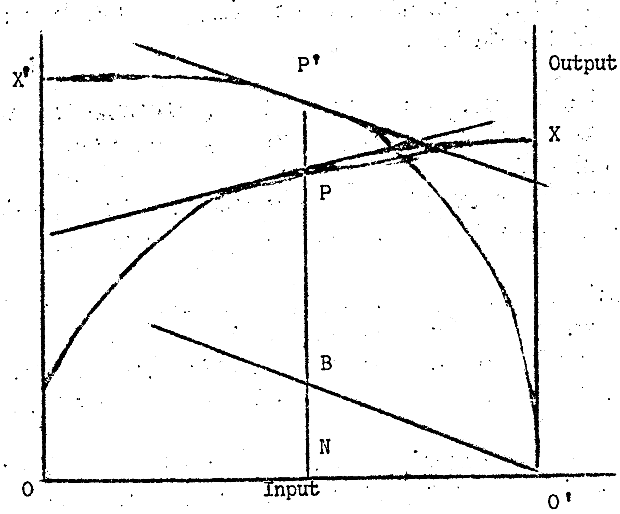


FIGURE 3.2



land, since this involves foregoing a return which could be received by hiring out to someone else. The usual approach can be seen in Figure 3.1. OX represents the response curve of output to incrasing application of draught power. The owner has a fixed amount of draught power available for a particular season, OA (say, pair-days or tractor-days). He uses ON himself and hires out NA. The hire rate is given by the market and is represented by the slope of AB.[1] Total net revenue is the value of production, PN, plus the amount received from hiring out, BN. This is at a maximum where the tangent at P is parallel to AB. In a two farmer model with one hiring in and one hiring out with identical responses per unit area to increments of draught power, the available resources would be divided in the ratio of their areas cultivated. If the responses are not identical there will be a shift of resources to the more productive (Figure 3.2).

The above assumes, of course, that what is paid by the hirer-in is the same as the amount received by the hirer-out. An important exception is where the hirer-in has to obtain credit from a third party in order to enable him to purchase the input (Figure 3.3).[2] The cost of credit increases the price to the hirer-in without changing the opportunity cost to the hirer-out. Where the hirer-out is also the money-lender it could be that a strong incentive to hiring-out his draught power is the opportunity to make additional money - or to gain social control - through the credit operation.

3.3: Indivisibility in Draught Services

Consideration of the lumpiness of draught services, rather than capital items, brings us back to the question of the appropriateness of "draught requirement" as a concept. What we are, in fact, interested in is the shape of the ceteris paribus production function. Figure 3.2 can be used to illustrate the usual economist's approach. The curve O P X, for example, represents the value of the total amount of output accruing as the level of hired input is increased. The slope O B represents the price of the input and P is the point at which the amount by which revenue exceeds cost is at a maximum, i.e. the point at which a tangent parallel to O B meets the curve.

---

[1] If the production function is $f(x)$, net revenue is $f(x)+(k-x)p$. This is at a maximum when $f(x)=p$, i.e. the same condition as if x were hired in (with the same second-order conditions).

[2] The equivalence of price and opportunity cost in the above requires an assumption that payment for hiring-out is received at the same time as the return from self-cultivation, i.e. at harvest. Hence if the hirer-in takes credit from a third party for this period, the model should, more realistically, show an increase in the opportunity cost to the hirer-out, depending on what opportunities are available to him to use the cash productively.

FIGURE 3.3

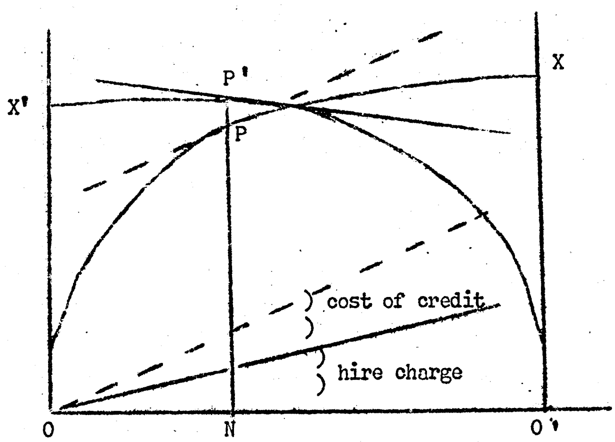


FIGURE 3.4

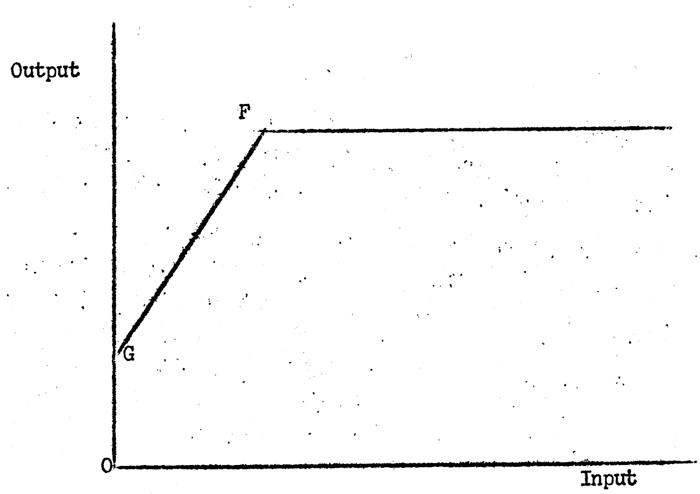


FIGURE 3.5

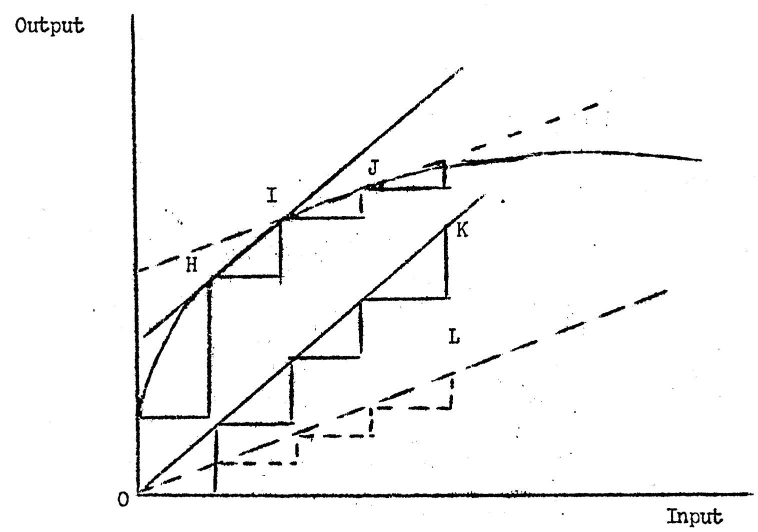


FIGURE 3.6

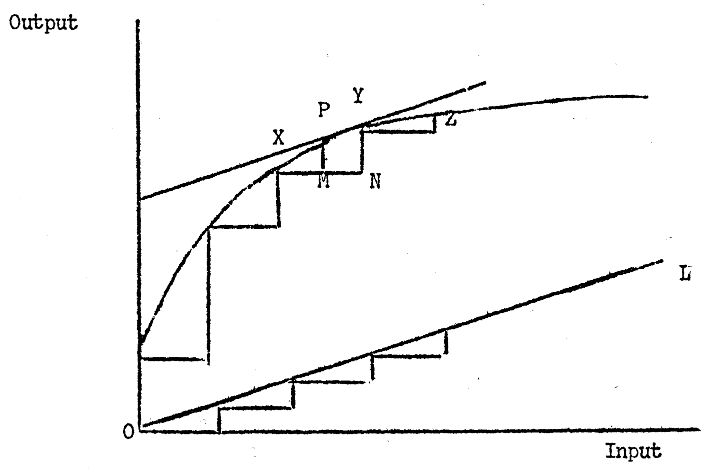
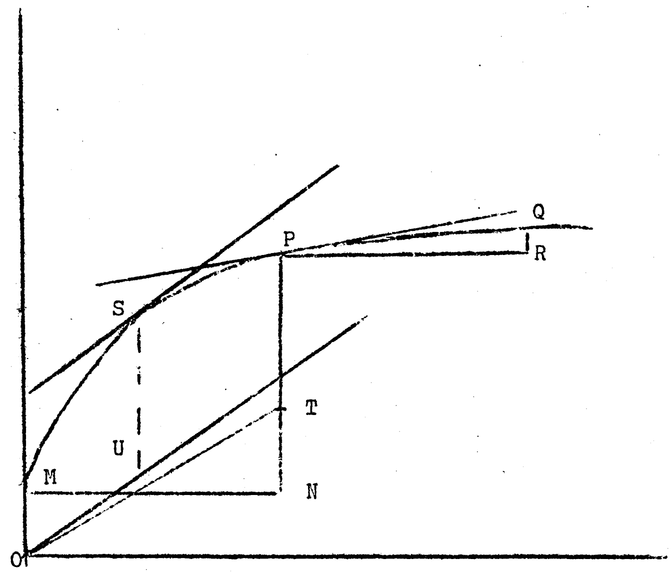


FIGURE 3.7



A "draught requirement" concept requires a particular shape of the curve relating input and output. In Figure 3.4, for example, the shape is not unlike the curves shown in the earlier figures except that there is a discontinuity in the first derivative at F. In this case any cost line which has a gradient between that of GF and the horizontal will produce an optimum at F. If the price is greater than the gradient of GF, it will be feasible to use the input. Hence the only optimal point on the curve is at F. Evidence for the existence of such a 'bent-stick' production response from experimental data from both the plant and animal sciences is referred to and some of its implications are discussed in Upton and Dalton (1976). They point out that aggregation from the plot or individual animal level is likely to produce the more familiar curvilinear function. An important implication is that the demand for the particular input on that particular plot by a profit-maximising farmer will be perfectly inelastic. He will have a fixed 'requirement' for the input at any price up to a certain maximum level.

A further model - and one which is possibly more realistic in the context of this study - is one in which inputs can only be supplied in discrete quantities. In this case the production response would be a step function with a uniform 'tread' and constantly decreasing 'rise', of which the envelope might be the traditional curve. The cost curve will also be a step function but with a uniform 'rise'. In Figure 3.5 the farmer can only produce at discrete points, i.e. H, I, J, etc.. If the cost curve OK rises at a rate equal to the slope of HI, he will be indifferent between points H and I of the production response curve, since the height above the cost curve of H and I is the same. If the cost curve OL rises at a rate equal to the slope of IJ then, similarly, the farmer will be indifferent between points I and J. In Figure 3.6, if the input is supplied at a price represented by the tangent at P, the amount demanded will be at X or Y depending on whether or not the height of P above X (PM) is less than or greater than one half of the height of Y above X (YN), i.e. whether unit cost is greater than or less than the slope of XY. Thus the demand function will itself be a step function; within each band of prices a fixed quantity will be demanded and this will change discontinuously as the price band changes (see Figure 3.7). Of course, if the envelope of the (stepped) production response function is a 'bent-stick' as in Figure 3.4, then once again there is a unique optimum at any price up to a certain level.

The type of production response function which has just been described would appear particularly applicable to the analysis of hired draught power, whether it be tractor or animal draught. In the case of tractor hire a standard product (in theory at least) is being supplied in fixed quantities. The hirer can buy one ploughing or two, but not one and a half. Normally, only a single ploughing will be demanded and the response function will have a single (large) step.

Hiring of animals is a little more complicated, since more passes are required to approach the optimum point. A number of possible hiring regimes may be analysed. In Comilla, contracts are made for a fixed number of ploughings and ladderings. No doubt, there is haggling over the criteria as to whether or not the contract has been completed, i.e. whether the requisite number of passes have been made to whether the field has been brought up to a recognisable standard of tilth. In either case, the situation is similar to that for tractor hire; a single unit is purchased at a price negotiated between the buyer and the seller. Also in Comilla, at a different season, cattle are hired for a single pass. In this case the hirer can decide sequentially how many passes he wishes to buy and the situation is that shown in Figure 3.5. In other areas, draught animals are hired per unit of time. If the units were infinitely small, the hirer would be able to choose the precise point on the curve in Figure 3.1 which maximises net revenue. The market does not, however, function like that. Although hire periods of less than a day do occur, far and away the most common is a whole day. Thus once again, we are in a situation where draught power is purchased in discrete quantities. In this case, though, there is an important difference. The lumpiness of the input will be determined by the amount of land to be ploughed. The larger the area to be ploughed the smaller the unit of input becomes on a per unit area basis. Indeed, it could be argued that for any but the very smallest farmers we are, for all practical purposes, dealing with a continuous variable. For example, let us suppose that a farmer has 1.47 acres to plough and he wishes to cover his fields four times each. Assuming that a bullock-pair can cover 0.3 acre in a day, they would require 19.6 days and the hirer has to choose between hiring for 19 or 20 days. On the other hand, if he only wishes to plough one quarter of an acre, the time required would be 3.3 days and the hirer has to choose between 3 and 4 days. He still, of course, has the problem of lumpiness in regard to a particular plot (see below).

It can readily be seen from Figure 3.5 that for any given envelope (what one might call the potential or underlying response function) the greater the steps, the broader the price bands within which each optimum is to be found. At the extreme, where there is effectively only one step, i.e. the tractor-hire case, the whole range falls within a single price band. This is illustrated in Figure 3.7. At a price per unit greater than PN (the slope of MP), none will be bought and production will be at M. At any price (except a very low one) one unit will be bought and production need not be at its physical maximum, that is on the horizontal part of the underlying response function.

The implication is that there is a difference between situations where the farmer is limited in choice to large-step technology (i.e. tractors) and where he is faced by small-step technology or has a choice of both. It is easiest to analyse if we compare a lumpy technology and an infinitely-divisible one.

Let us assume that there is an infinite supply of divisible technology at a price represented by a tangent to the curve at the point P (Figure 3.7). This is the only point at which the user will be indifferent between the lumpy and the divisible technologies. At any other price the lumpy technology will have to be offered at a unit price lower than that of the divisible technology in order to compensate the user for having to use it in 'uneconomic' quantities. In Figure 3.7 the price of the divisible input is represented by OU which is parallel to the tangent to the underlying production function at S and the excess of revenue over cost is given by SU. For the user to be indifferent between the two technologies the price of the lumpy one has to be given by the slope of the line OT where SU=PT.

Of course, whether the supplier of the lumpy input will be prepared to supply at this price will depend on the costs which he has to meet.

Analysis of the case in which there are technologies with different degrees of lumpiness is a little more complicated. Nonetheless, the principles are the same. If the P of Figure 3.7 coincides with X, Y or Z of Figure 3.6, there will be a price range within which the hirer is indifferent between the two technologies. Outside this range, price will favour the less lumpy of the technologies. If the P of Figure 3.7 does not coincide with X, Y or Z, then there will be a short range of prices within which the more lumpy technology is favoured, and outside this the less lumpy will have an advantage. This assumes, of course, that the two technologies are offered at the same unit price. The model can provide an explanation of how it is possible for technologies of different degrees of lumpiness to co-exist in the market at different unit prices. If producers have different production functions, the ranges of price within which one technology is preferred to another will differ.

To each production function there corresponds a demand curve for the input in question. The importance of the above analysis is that, if the response to an input is stepped, then the demand for that input will also be stepped. The lumpier the technology, the broader will be the price bands within which demand is perfectly inelastic. Individual demand curves can be aggregated to provide a demand schedule for a community as a whole. It will be noted that the aggregated demand function of stepped individual functions will also be stepped. However, as the number of individuals increases the aggregated demand function will approximate a smooth function.

Bangladeshi farmers exhibit a high preference for the 3 or 4 ploughings and ladderings which will produce a 'jo' condition. This suggests that their perception, at least, of the underlying production function is something approaching that in Figure 3.4. The implication is that the demand for draught power is probably highly inelastic in the relevant portion of the curve. Thus the notion of a 'draught power requirement' seems reasonably realistic.

It is now possible to consider the case where there is a mixture of technologies. It is very common for farmers who have their land tractor-ploughed by BADC to add a further animal-draught cultivation before planting. It has been suggested that the purpose is to level the land rather than necessarily improve the quality of tilth. Nonetheless, it represents an advance up the production function with an associated cost and hence can be accommodated by the model.[1]

---

[1]There is an assumption, of course, that the different technologies can be represented by the same underlying production function. This is less restrictive than it seems, since the horizontal scale used to represent increments of each technology can be chosen at will. If, in the range of interest, one of the technologies has effectively a single unit, the problem disappears.

Thus if the point P of Figure 3.7 falls sufficiently far to the left of X in Figure 3.6, it will be worthwhile adding an additional animal-draught 'step'. Indeed, a mixture of technologies gives more flexibility in attempting to reach the optimum part of the curve.

3.4: Adequacy of Draught Power

We are now in a position to consider the distribution of draught power and the extent to which any farmer's available draught power is adequate to his needs. The problem with using draught-pairs per acre or installed horsepower per acre as a measure of draught adequacy is that it turns into a continuous variable what is essentially a discrete phenomenon. A possible approach is shown in Figure 3.8. It has already been remarked that the critical period is the aus/aman turn-around. If we assume that 24 days is available from the aus harvest for land preparation and that a pair of draught animals can cover one-third of an acre per day, then it will be possible for a pair to plough 8 acres once during the period. They will be able to cover 4 acres twice and two and two-thirds acres 3 times. Each of these options is represented by the rays in the diagrams of Figure 3.8. The numbers falling in each band are shown in Table 3.1. The width of the bands need not, of course, be constant. If successive passes can be made more quickly, then the band widths can be narrowed accordingly.

TABLE 3.1: ADEQUACY OF AVAILABLE ANIMAL DRAUGHT

Number of farms

	Inadequate for one pass	Adequate for one pass or more	Adequate for two passes or more	Adequate for three passes or more	Total
Rangpur	7	29	16	5	36
Bogra	10	26	14	11	36
Dacca	13	59	39	22	72
Comilla	31	41	30	23	72
Noakhali	49	23	10	4	72
Munshiganj	52	20	13	8	72

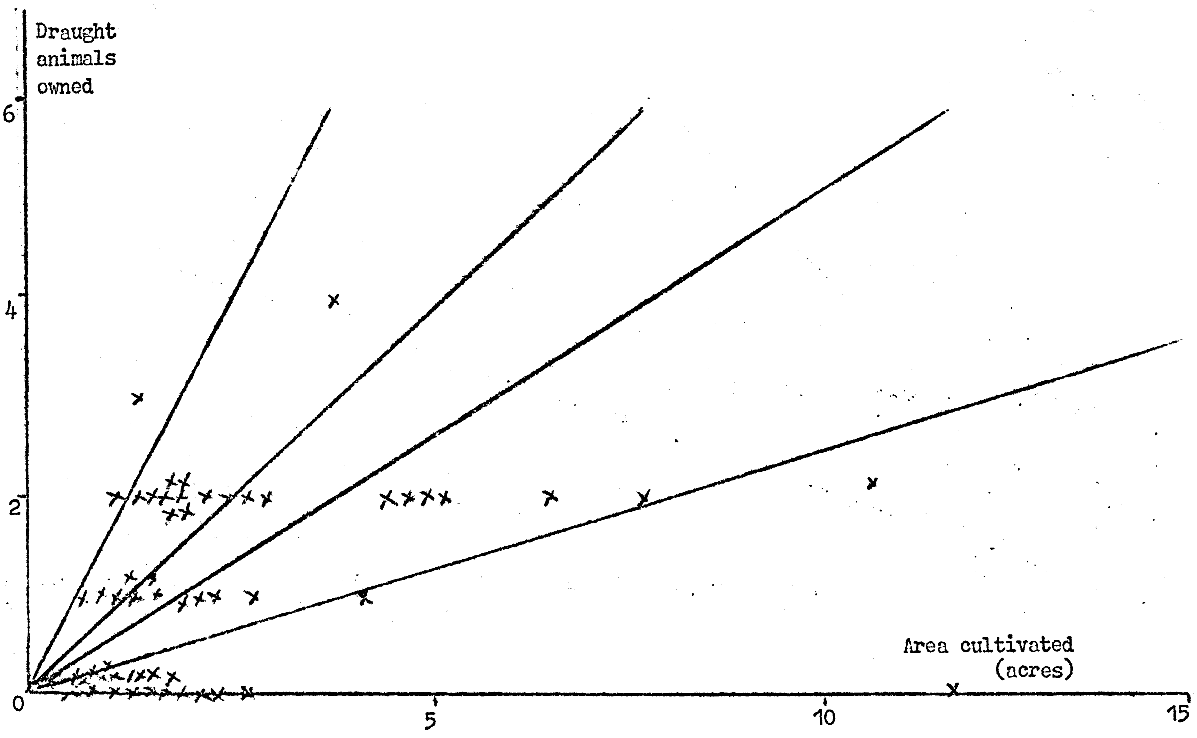
Except in the case of Noakhali, virtually all of those with inadequate draught power for even a single pass have no draught animals at all. In Noakhali the situation is complicated by the presence of char lands. These do not grow an aus crop and are prepared well in advance of those nearer to the village.

It is interesting to compare Rangpur and Comilla on the basis of this analysis. Although there is a better distribution of draught animals per farm in Rangpur, holdings are smaller in Comilla. Hence, the proportion of farmers who can cover their available acreage is greater in Comilla. In none of the areas do more than one-third of the farmers have enough draught animals for three or more passes.

Attempts have been made to calculate Bangladesh's overall draught requirement on the basis of the known total of cropped or cultivated acres and a coefficient relating draught availability to the area

FIGURE 3.8: ADEQUACY OF AVAILABLE ANIMAL DRAUGHT

COMILLA



NOAKHALI

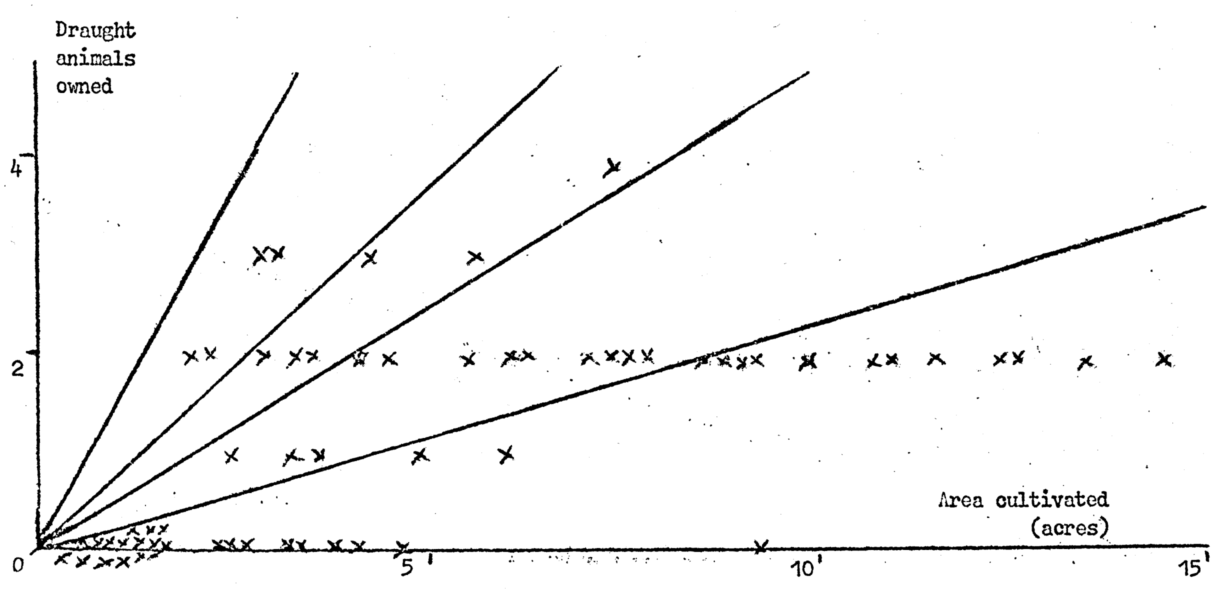
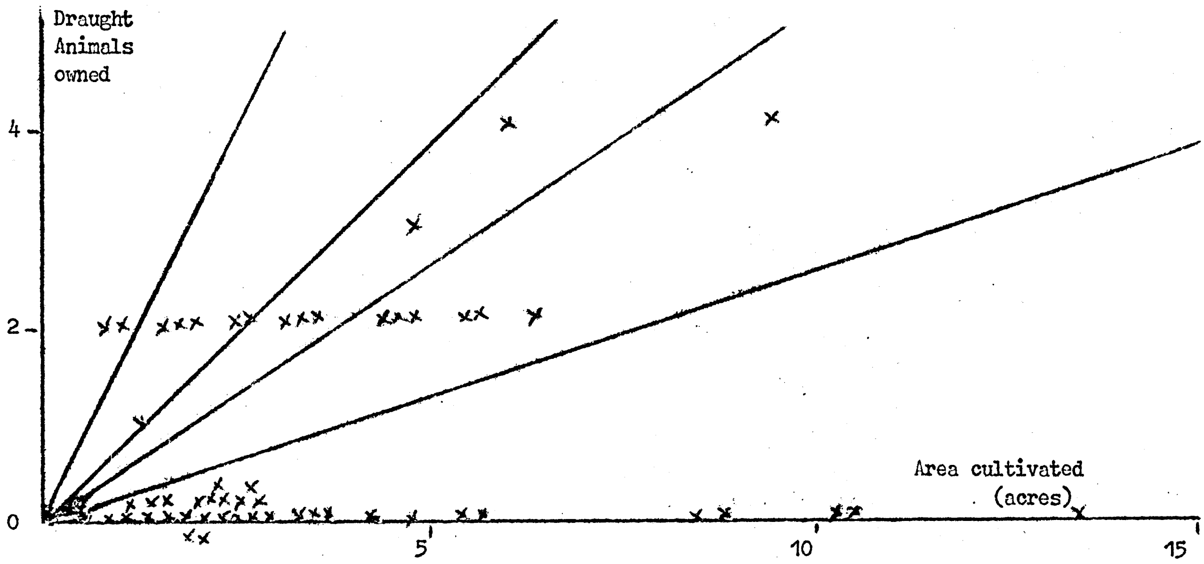


FIGURE 3.8 (Continued)

MUNSHIGANJ



DACCA

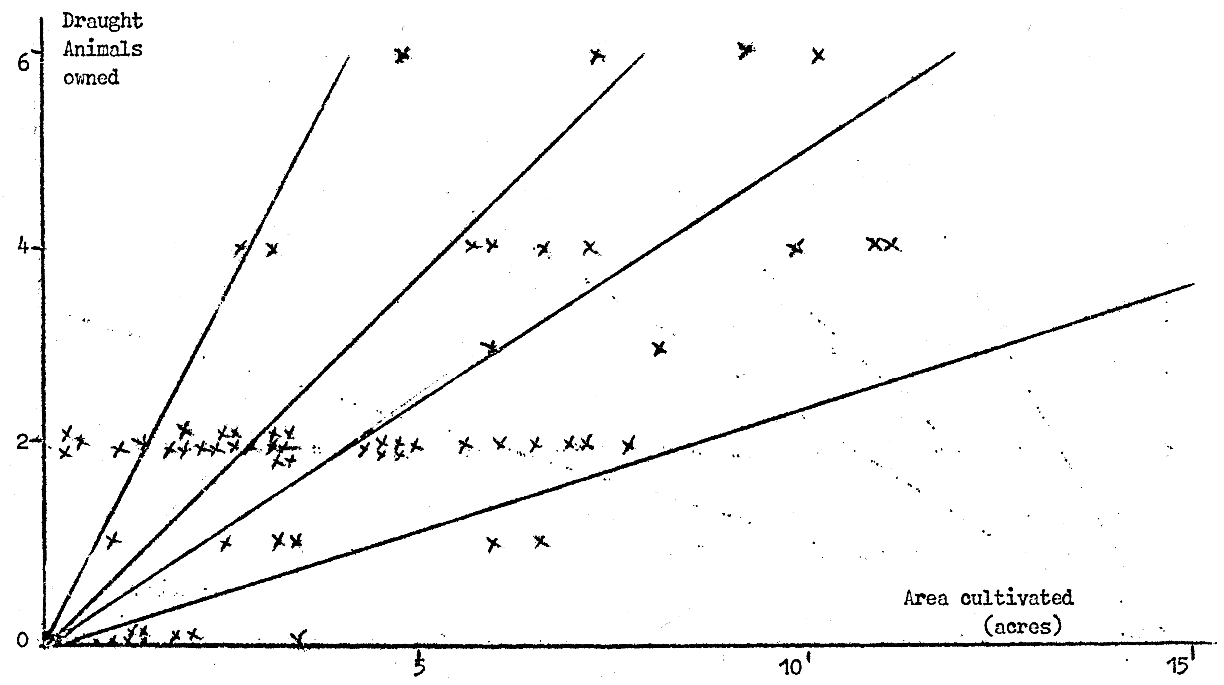
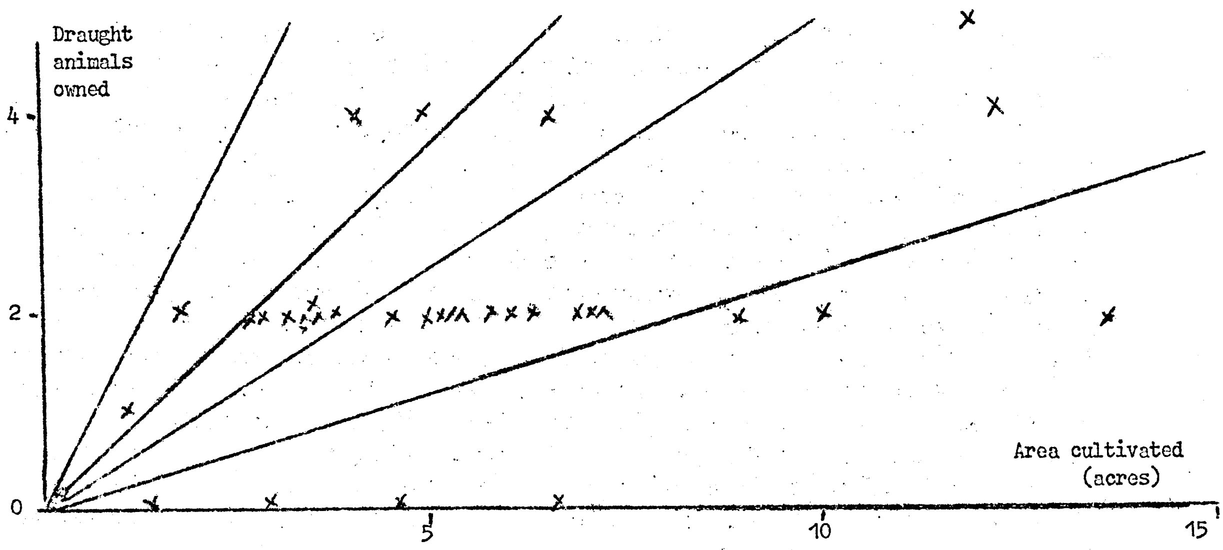
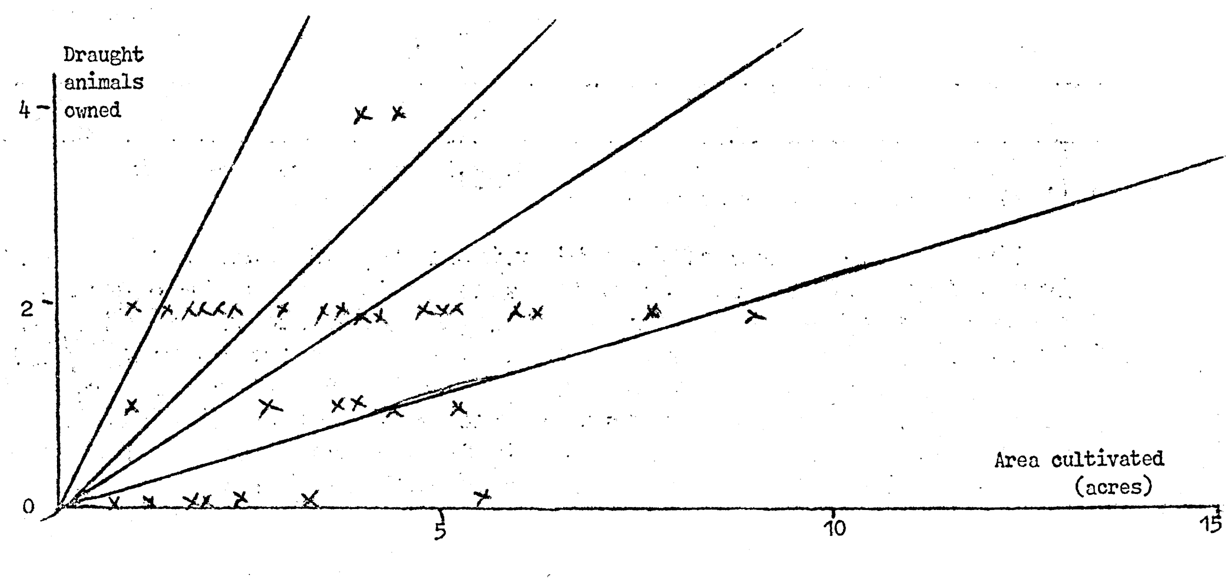


FIGURE 3.8 (continued)

RANGPUR



BOGRA



cultivated. Cultivated area would seem to be more appropriate than cropped area, since cultivation in one season is not competitive with cultivation in another, except very marginally where there is an extreme nutritional constraint. A rule of thumb which is often used is one pair per four acres. On this basis, since the total cultivable area is 22.5 m. acres, the total draught requirement is 5.6 m. pairs, compared to an estimated availability of about 5.8 m., including buffaloes, and counting a cow as equivalent to a bullock.

It will be seen from Table 4.1 that in only one of the ten villages surveyed was there a pair of oxen to every four cultivated acres, even if females are treated on a par with males. This cannot be attributed to mechanisation; three villages had no, or virtually no, access to mechanical draught, two had only very limited access, and in only one was there a free availability. In none of the villages where four-wheel tractors were available was the service sufficiently reliable to encourage farmers to dispose of their oxen. In two regions the more mechanised village had more oxen per acre than the less mechanised. In fact, it is shown in Table 3.2 that farmers who hire tractor services own more oxen per acre than those who do not in three out of five villages. One of the two villages where hirers own fewer draught animals is the only one in the table where a commercial rate is charged, i.e. village 9, where privately-owned power-tillers from village 10 are brought in. In this village only one of the hirers owns any draught animals, whereas ten of the non-hirers are owners.

TABLE 3.2: DRAUGHT ANIMAL OWNERSHIP BY TRACTOR/TILLER HIRERS AND NON-HIRERS

Village	Tractor/Tiller Hirers		Non-hirers	
	n	Mean Number of Draught Animals	n	Mean Number of Draught Animals
1	21	2.1 (0.25)	15	1.7 (0.27)
4	30	2.0 (0.20)	6	1.5 (0.34)
6	11	0.6 (0.20)	25	1.1 (0.19)
7	17	1.1 (0.31)	19	0.9 (0.27)
9	8	0.3 (0.25)	28	0.8 (0.20)
TOTAL	87	1.5	93	1.1

Note: Villages 2, 3, 5 and 8 have no access to tractors; Village 10 is almost entirely mechanised. Figures in parentheses are standard errors.

The average number of draught animals is, of course, not a very relevant figure. There is considerable variation in the ownership of draught animals, not only between villages, but also within villages (Figure 3.8). If there is a well-developed hire market with draught animals available in timely fashion at a price the poorer farmers can afford, the effects of a skewness in the distribution of ownership are less severe than where these conditions do not hold. The question of the distribution of ownership is discussed in Chapter 6.

CHAPTER 4: THE USE OF COWS FOR DRAUGHT

4.1: Cows as Draught Animals

A possible indicator of the shortage of draught power is the use of female cattle for cultivation. Traditionally only oxen were used and it is claimed that the use of cows for ploughing is relatively recent. Table 4.1 sets out some of the data relating to this issue from the farms sampled in the ten villages surveyed. It will be seen that practices vary from one village to another.

Rangpur might be said to follow the classic pattern. Only one of the 36 farmers sampled owned no animals and only three owned no draught animals. This village has the highest number of animals per farm as well as the greatest number of draught animals. Only two farmers use females for cultivation, yet the total availability of draught oxen is less than one pair to five acres. Village 5 in Comilla is similar; it has fewer draught oxen, but the area to be cultivated is much less so that per acre availability is actually greater. Following Gill, females have been rated at 60% of males in terms of their draught capability (See Volume I, Appendix 7). Clearly, the ox-pair equivalent (or installed horse-power) will be very dependent on this assumption in those cases where the proportions of draught females is high, i.e. Dacca and Bogra (see Table 4.2). In fact, one of the Dacca villages has the greatest per acre availability of draught power of all the villages, while at the same time having a draught animal population which is very nearly half female. The coefficient relating female draught power to ox power could be reduced to below 20% before this village fell below Rangpur as regards draught availability. Hence it would appear to be from choice rather than dire necessity that farmers in this village keep such a high proportion of dual-purpose cows. In Comilla one of the villages specialises in milk production for Comilla town and this appears to add a number of dual-purpose females to the draught herd.

Farmers in the Bogra village also seem to have made a positive choice to keep dual-purpose females. All except one of the animals owned by sampled farmers is used for draught and the over-riding majority is female. It is somewhat worrying that no calves are recorded, in spite of there being 45 cows kept for milk as well as cultivation. Particularly, since it is generally accepted that bos indicus cows need a calf at foot if they are to continue producing milk. The most probable explanation is that this is due to a misunderstanding on the part of field staff; this was the first time that the survey had taken an interest in animals of this age. The calculation of ox pair equivalent per acre for this village is extremely sensitive to the assumed strength of cows relative to oxen. If draught cows were rated as fully equal to a male, then this village would be no worse off than any other except the Dacca villages.

Noakhali was included in the survey specifically because it was seen as an area where shortage of draught power is likely to be constraining. Apart from Munshiganj, which is quite heavily mechanised, this area has the lowest per acre availability. The acreage

TABLE 4.1a: THE USE OF COWS FOR DRAUGHT

	Village	No. of Cattle	Ave. Herd Size	No. of Draught Owners	No. of Draught Animals 3 yrs. & older Total	Male	Female	Females 3 years and older
RANGPUR	1	138	3.8	33	72	69	3	35
BOGRA	2	51	1.4	28	50	6	44	45
DACCA	3	117	3.3	30	83	42	41	50
	4	84	2.3	32	69	41	28	32
COMILLA	5	58	1.6	23	41	38	3	13
	6	102	2.8	26	35	24	11	42
NOAKHALI	7	44	1.2	17	36	31	5	10
	8	85	2.4	24	50	34	16	33
MUNSHIGANJ	9	59	1.6	14	22	22	-	16
	10	71	2.0	11	24	22		24
TOTAL		809	2.2	238	482	329	153	300

TABLE 4.1b:

	Village	Draught Females as % of Females 3 yrs. and older	Draught Females as % of Draught Animals	Ox-pair Equivalent per acre (1)
RANGPUR	1	9	4	0.18
BOGRA	2	98	88	0.13
DACCA	3	82	49	0.24
	4	88	41	0.17
COMILLA	5	23	7	0.20
	6	26	31	0.17
NOAKHALI	7	50	14	0.08 (2)
	8	48	32	0.12 (2)
MUNSHIGANJ	9	-	-	0.12
	10	8	8	0.18 (3)
TOTAL		51	32	0.15

Notes: (1) Females rated at 60% of males (see Appendix 7, Vol. I). Figures shown are average of farm level figures weighted by area.
(2) Char lands included in the denominator.
(3) Power tiller owners included.

TABLE 4.2: SENSITIVITY OF CALCULATION OF OX-PAIR EQUIVALENT PER ACRE TO COW/OX RATIO

Cow/Ox Ratio Assumption		1.0	0.9	0.8	0.7	0.6	0.5
Village:							
Rangpur	1	.18	.18	.18	.18	.18	.18
Bogra	2	.20	.18	.16	.14	.13	.11
Dacca	3	.30	.28	.27	.25	.24	.23
	4	.21	.20	.19	.18	.17	.17
Comilla	5	.20	.20	.20	.20	.20	.20
	6	.19	.18	.18	.17	.17	.16
Noakhali	7	.09	.09	.08	.08	.08	.08
	8	.14	.14	.13	.13	.12	.12
Munshiganj	9	.12	.12	.12	.12	.12	.12
	10	.09	.09	.08	.08	.08	.08

of these two villages, particularly village 7, tends to be exaggerated by the inclusion of relatively recently formed char land which is cultivated in large tracts in an extensive manner, but only in the aman season. Land preparation takes place before the major aman land preparation in the village and hence is not really competitive. However, even if allowance is made for char lands, per acre availability only increases by some 15%. In spite of their apparent lack of draught power, only about half of the adult females are used for cultivation.

4.2: Fertility of Draught Females

In terms of purely technical efficiency the use of females could prove costly, not only from the point of view of cultivation, but also in terms of livestock products and, perhaps most important, vouchsafing the future of the herd. It is not simply that females are likely to be smaller and weaker than oxen, but also less dependable, since there will be periods when they are unable to work before and after calving. It might be mentioned that very heavily pregnant cows can be seen working the fields in some areas. Animal production might be affected in a number of ways through reduced fertility, lower milk yields as a result of fewer lactations as well as less milk per lactation, and through increased susceptibility to disease due to the combined stress of pregnancy and heavy work.

An attempt has been made to estimate the difference in fertility between cows which are used for cultivation and those which are not. Respondents were asked a number of questions about each of their cattle. Questions included the age and sex of each animal and the purposes for which it is kept. All adult females fell into one of three categories for the purpose of this analysis: milk only; milk and cultivation; and breeding. It was not possible to establish uniquely which cow was the mother of each calf. However, it was possible to categorise each farm as to whether it kept cows for milking and breeding only, for milking and cultivation only, or a mixture of both. Only 6% of the farms kept both types of cow and these were almost all in the specialist milk producing village near Comilla town. Thus, although it was not possible, in general, to tell which cow was the mother of a particular calf, we know whether the mother was used for cultivation or not since all the cows on the farm were either used for cultivation or were not. Of the 94% of farms which could be uniquely ascribed in this way half kept only milking-breeding cows and the other half kept only draught females. Almost all of the latter groups were described as being kept for draught only. The proportion of cows to calves was calculated in each of the three categories for calves less than one year of age and, since the number of these was relatively small, also for calves younger than three years. A minimum cut-off age for the cows had to be specified, since the potential purpose of young animals had been recorded in some areas rather than their actual occupation. The results are shown in Table 4.3. The weighted average of the ratio of calves younger than three years to cows was 79%. 35% and 68%, respectively in the three categories.[1]

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[1] Omitting the anomalous Bogra data.

TABLE 4.3: COW/CALF RATIOS FOR DRAUGHT AND NON-DRAUGHT COWS

Village		FARMS WITH ONLY MILKING-BREEDING COWS						FARMS WITH ONLY MILKING-DRAUGHT COWS						FARMS WITH BOTH						
				Calves less than 1 year		Calves less than 3 years				Calves less than 1 year		Calves less than 3 years					Calves less than 1 year		Calves less than 3 years	
		No. of cows	No. of farms	No.	% of cows	No.	% of cows	No. of cows	No. of farms	No.	% of cows	No.	% of cows	No. of milk cows	No. of draught cows	No. of farms	No.	% of cows	No.	% of cows
Rangpur	1	29	17	8	28	26	90	3	2	1	33	4	133	-	-	-	-	-	-	-
Bogra	2	-	-	-	-	-	-	41	24	-	-	-	-	1	2	1	-	-	-	-
Dacca	3	7	6	2	29	6	86	40	21	6	15	15	38	-	-	-	-	-	-	-
	4	2	2	-	-	-	-	24	18	4	17	7	29	-	-	-	-	-	-	-
Comilla	5	9	8	2	22	2	22	3	2	-	-	-	-	-	-	-	-	-	-	-
	6	20	15	12	60	20	100	4	4	1	25	1	25	9	6	6	7	47	11	73
Noakhali	7	4	4	-	-	2	50	5	3	-	-	-	-	-	-	-	-	-	-	-
	8	13	8	5	38	10	77	12	7	4	33	5	42	2	2	2	1	25	2	50
Munshiganj	9	7	7	2	29	7	100	-	-	-	-	-	-	-	-	-	-	-	-	-
	10	18	14	6	33	13	72	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL		109	81	37	34	86	79	132	81	16	12	32	24	12	10	9	8	36	13	59
TOTAL (Less Village 2)		109	81	37	34	86	79	91	57	16	18	32	35	11	8	8	8	42	13	68

Notes: Only cows 4 years and older are included.
A small number of calves bought in has been excluded.
A small number of calves on farms without cows has been excluded.

The results suggest that the calving percentage for draught cows in only about half of that for cows which are not used for cultivation. In order to provide a statistical test of this result, the ratio of calves to cows was calculated for each farm in each of the two major categories and summary statistics produced for the sample as a whole with the following results:

Calf/cow ratio

	Calves less than one year		Calves less than three years	
	Farms with only milking cows	Farms with only draught cows	Farms with only milking cows	Farms with only draught cows
n	81	57	81	57
mean	0.339	0.206	0.789	0.355
variance	0.209	0.144	0.357	0.267
S.E.	0.023	0.019	0.039	0.035

The difference between the means is significant at a 5% level (one-tail test) for the ratio of calves less than one year and at a 0.01% level for the ratio of calves less than three years.

4.3: Interpretation of Result

One must be careful in drawing inferences from this result. It is possible that there is under-reporting of calves. It has already been remarked that no calves were reported from the village in Bogra, and hence this whole village has been omitted from the analysis. All the other areas included calves and the results are broadly consistent - given the small numbers involved - between one village and another (see Table 4.3 and Figure 3.2.) It is not, therefore, unreasonable to assume that, if any calves have been left out, they have been omitted at random. Calves might also have been sold, although any sold during the previous year would have been reported. Only one calf was reported sold and that was three years old.

It could be argued that the data in Table 4.3 merely reflect a tendency among farmers to retain their barren females for cultivation while reserving the productive ones for milk and breeding. Where they have a choice, it would be surprising if they did not make this decision. However, if this were common, one would expect to see a mixture of cultivating and non-cultivating cows, if not on the same farm, at least in the same village. A mixture on individual farms would be unlikely, since the numbers kept are so few. We note, however, in Table 4.4 that of 81 farms with more than one cow, only 9 had a mixture. Similarly, looking again at Table 4.1, it can be seen that three villages have predominantly breeding-milking cows, three have predominantly draught cows, and the remaining four have more of a mixture.

It would make sense for those with adequate draught power to sell off their barren females. These could provide an inferior, though presumably cheap, alternative to draught oxen. Some 54% of cows aged three years and over have been bought by their current owner. The data were tested to see whether there is any significant difference between the proportion of milking-cultivating cows

TABLE 4.4: NUMBERS OF COWS PER FARM

		Farms with only milking-breeding cows				Farms with only milking-cultivating cows				Farms with Both			
Numbers of Cows:		1	2	3	4	1	2	3	4	1	2	3	4
Farms with calves younger than 3 years	Village												
	1	9	5	2	1	1	1	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-	-	-	-	-
	3	4	1	-	-	1	6	3	-	-	-	-	-
	4	-	-	-	-	4	1	-	-	-	-	-	-
	5	2	-	-	-	-	-	-	-	-	-	-	-
	6	9	4	-	-	1	-	-	-	-	3	3	-
	7	2	-	-	-	-	-	-	-	-	-	-	-
	8	3	5	-	-	-	2	-	-	-	2	-	-
	9	6	-	-	-	-	-	-	-	-	-	-	-
	10	5	4	-	-	-	-	-	-	-	-	-	-
		40	19	2	1	7	10	3	-	-	5	3	-
Farms with no calves	1	-	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	7	17	-	-	-	-	1	-
	3	1	-	-	-	4	7	-	-	-	-	-	-
	4	2	-	-	-	8	5	-	-	-	-	-	-
	5	5	1	-	-	1	1	-	-	-	-	-	-
	6	3	-	-	-	1	1	-	-	-	-	-	-
	7	2	-	-	-	1	2	-	-	-	-	-	-
	8	-	-	-	-	2	3	-	-	-	-	-	-
	9	1	-	-	-	-	-	-	-	-	-	-	-
	10	5	-	-	-	-	-	-	-	-	-	-	-
		19	1	-	-	24	36	-	-	-	-	1	-

TABLE 4.5: PERCENTAGE OF DRAUGHT AND NON-DRAUGHT COWS BOUGHT

Village	Milking-Cultivating Cows			Milking-Breeding Cows			Other	Significance
	No. Bought	Total	%	No. Bought	Total	%		
1	2	3	67	6	30	20	2	
2	36	44	82	-	1	-	-	
3	20	41	49	5	7	71	2	
4	15	28	54	-	4	-	-	
5	2	3	67	6	9	67	1	
6	5	11	45	17	30	57	1	N.S.
7	-	5	-	3	4	75	1	
8	10	16	63	8	17	47	-	N.S.
9	-	-	-	6	10	60	6	
10	-	2	-	13	19	68	3	
TOTAL	90	153	59	64	131	49	16	*

Note: Cows three years of age and over.
*Proportions significantly different in a one-tail test at 5% level of significance.

which were bought and the proportion of milking-breeding cows bought. Two villages have sufficient observations to allow a significance test of the difference in proportions. Neither of these proved significant. However, the overall difference was significant at a 5% level (one-tail test). The results are set out in Table 4.5.

If farmers buy barren females for draught purposes, it would be reasonable to expect them to own them in pairs, whereas those females which are just used to make up draught numbers are more likely to be owned in singletons as are pure milch cows. A null hypothesis could be formulated as follows: among those farms which keep cows for draught purposes, there is no significant difference in the proportion of single cows owned between those farms with calves and those without. The data for such a test are provided by Table 4.4. The difference in proportions proves not to be significant. On the other hand, the difference between the proportion of single cows on farms with only milking-breeding cows and the proportion on farms with only draught cows is highly significant, (significant at a 0.1% level even if the Bogra village is excluded). It can be seen that the tendency to own pairs of draught females is most marked in the Bogra village which, incidentally, has the highest proportion of draught females bought in. Unfortunately there are not sufficient bought animals in each category in any location to make price comparisons meaningful, since purchases have been spread over a dozen years of rising prices.

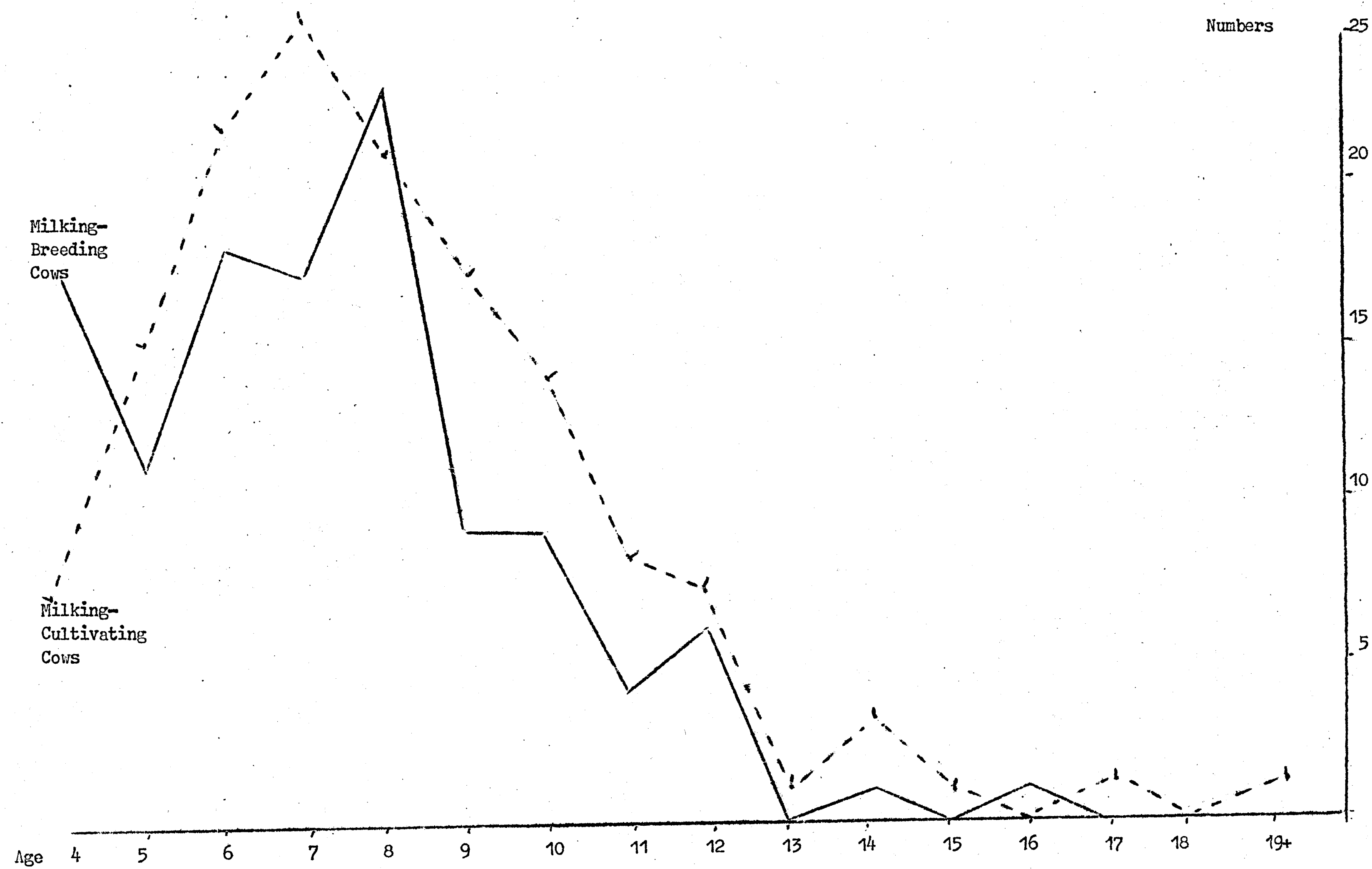
Age profiles for both milking-breeding and milking-cultivating cows aged four years and older are shown in Figure 4.1. The hypothesis was that draught cows would be considerably older than milking-breeding cows. The mean ages of the two herds are 7.4 years and 8.0 years, respectively and the difference is just significant at a 5% level (one-tail test). After the age of four there is little to choose between the profiles; mean ages for cows of five years and over in the two groups are 8.03 and 8.25 years, respectively (non-significant). This suggests that many cows are not put to the plough until after they have had their first calf, although it should be remarked that many respondents replied with what they intended animals to do - even small calves - rather than what they were actually doing.

4.4. The Opportunity Cost of Draught Females

If it is accepted that there is a difference in reproductive rates between females used for draught and those which are not, then clearly there is an opportunity cost involved. Calculation of this opportunity cost has to await the development of a model in Chapter 5 which relates the cost of maintaining draught animals to the size and structure of the herd needed to replace them. Since the focus of interest in the next chapter is on the overall cost of providing animal draught power, it is worthwhile repeating the conclusions relating to the use of females for draught in this chapter in order that their significance is not lost.

Two components of the opportunity cost are considered independently, the loss of milk production and loss of calves. The loss of milk is calculated only on the basis of less frequent lactations. On one particular set of mortality assumptions it is shown that to provide one ox-equivalent per year leads to a reduction in milk production of approximately 35 seers of milk per year, if the use of females for draught leads to a fall of 15% in calving percentage.

FIGURE 4.1: AGE PROFILES OF DRAUGHT AND NON-DRAUGHT COWS



The cost resulting from the loss of calves is calculated on the basis of changes in the size and structure of the herd necessary to ensure that the herd exactly replaces itself with a given number of oxen and working females. The parameters needed are age-specific mortality rates and the different reproductive rates of the working and non-working adult female populations. It is shown that, provided that calving percentages are high enough, it pays to use all the adult females for draught. However, if the use of females for draught pushes the calving percentage below the critical level, then it is impossible to maintain the size of the herd. The process is an insidious one, because given normal fluctuations from year to year, the decline may go unnoticed until it has reached an advanced stage.

CHAPTER 5: THE COST OF ANIMAL DRAUGHT

5.1: The Problem of Draught Costs

Calculation of the cost of machine power, either from a private or a social point of view presents few problems. For draught animals it is less straightforward. Frequently, few of the costs involved are direct costs. Indeed, it is perfectly possible to keep draught animals without spending a penny on them, either for purchase or maintenance. If the animals are born on the farm and are fed on crop residues or forage for their existence, then the cash cost is nil.

One approach is to take the cost as equal to the hire charge in the same way that one might take the cost of land as equal to its rental. For those farmers who own their own draught animals there is an opportunity cost of using them on their own land equal to the income foregone by not hiring them out. This, taking into account any transaction costs, is equal to the hire charge. In the long-run, the marginal cost of production of a draught animal will be equated to its hire charge, under competitive conditions, since if the hire charge is lower or higher than this, farmers will be discouraged from or encouraged to produce calves, and rear them for draught animals.

Another approach is to treat a bullock rather as though it were a machine and to calculate its fixed and variable costs. Details of such a methodology are set out in CEEMAT/FAO (1972). This was the method used by both the then EPADC (now BADC) and Mian and Hussain to compare the costs of cultivation by power tiller and by animal draught (EPADC, 1970, and Mian and Hussain, 1975). EPADC calculated on the basis of hypothetical costs over a full year, whereas Mian and Hussain used actual costs incurred during the aman season, 1970. Nonetheless, the cost items included in the calculation were virtually identical: depreciation and interest on the capital value of the stock, housing, veterinary charges, feed, and labour for daily maintenance. Against these costs both offset the value of dung. Mian and Hussain valued the stock at the beginning and end of the period and included a value for appreciation or depreciation after adjusting for any bullocks which were purchased, sold or butchered or which died during the period. On both pure bullock farms and on mixed bullock-power tiller farms there was net appreciation. It is not clear how the valuations were made, but it is not uncommon in countries in Africa for farmers to sell their working oxen after several years at a higher price than they paid for them, simply because they have grown during the period of ownership (CEEMAT/FAO, 1972). Of course, after a while the rate of increase slows down or ceases and there is then a trade-off between the cost and trouble of training new oxen and the opportunity cost of lost appreciation. Also, in countries where animal draught is competitive with beef production and there is a sophisticated marketing system, there is an opportunity cost involved in using oxen for draught represented by possible loss of grade at slaughter (Harvey, 1973). The results are compared with a similar calculation for 1979 from the data provided by this survey in Table 5.1.

TABLE 5.1: THE COST OF BULLOCK CULTIVATION IN 1970 and 1979

In this Table bullocks are treated as a capital item with their capital cost given by their purchase price

	1970 (Rs. per pair) Full Year (1)	1970 (Rs. per pair) Aman Season (2)	1979 (Taka per pair) Full Year (9)
Depreciation	75.00 (3)	24.16	362 (10)
Interest	14.00 (4)	19.70 (5)	300 (11)
Housing	70.00	5.26	- (12)
Veterinary charges	12.00 (6)	3.40	100
Feed	365.00 (7)	127.40	1400
Labour for daily maintenance	182.00 (8)	39.20	- (12)
	718.00	219.12	2162
LESS			
Manure	45.00	12.25	268
Appreciation		30.13	
	673.00	176.74	1894
Cost per acre		64.25	

NOTES

(1) EPADC (1970)
(2) Mian and Hussain (1975) - bullock only farms
(3) Cost Rs.600
Salvage value Rs.150 (25% of cost)
Useful life 6 years
(4) At 6%
(5) At 7%
(6) At 2% of cost
(7) Rs. 1 per pair per day
(8) Rs. 0.50 per pair per day
(9) Data from this study
(10) Ave. from all areas 4425 takas per pair depreciated over 10 years (residual value 800 taka)
(11) At 11½%
(12) Opportunity cost taken as zero.

5.2: Bose & Clark Model

Bose and Clark (1970) consider that both of those approaches are inappropriate. Each of them depends upon implied conditions of perfect competition, the first in the animal hire market and the second in the animal purchase market. It is not so much, however, the rejection of this assumption which causes them to look for a different line of attack. It is the way that these calculations have been used to justify savings from partial mechanisation. Thus, if the hourly cost of cultivation is calculated by dividing the total animal cost by the number of hours the bullock works per year, the apparent saving is over-estimated. This is what they call the "famous fuzzy thought on fodder feeding". There are only minor variable costs associated with the use of animal power. The only way to save the supposed costs is to get rid of the animal.

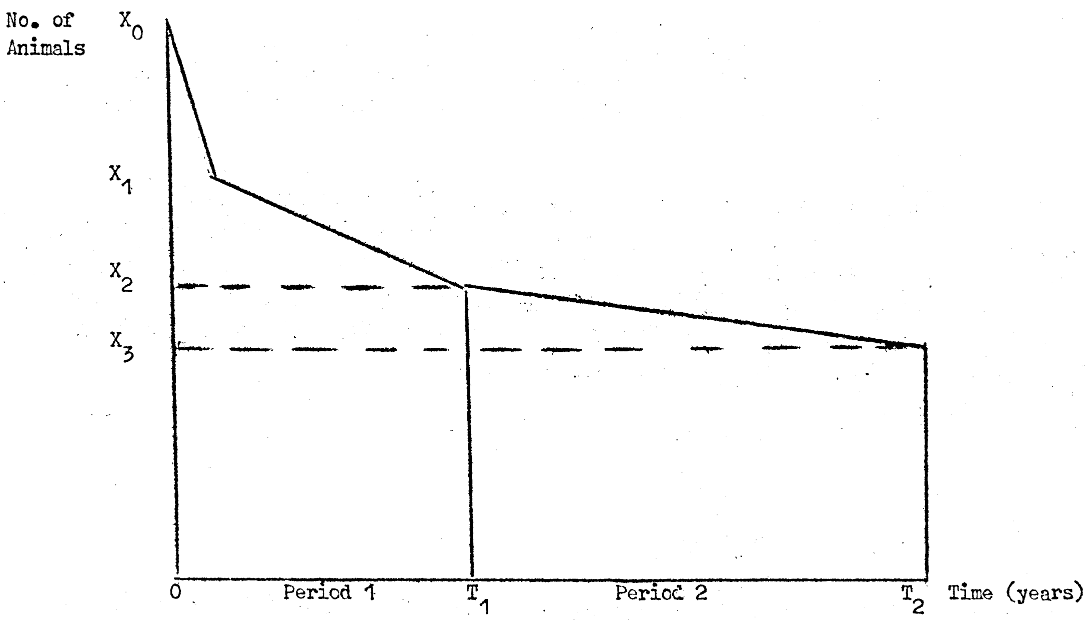
If it is the social cost of animal draught that we are interested in, it is necessary to examine how closely market costs reflect social costs. Since virtually the entire cost of animal power is a fixed cost, we have to determine what this cost is. The advantage of trying to disentangle the components of this fixed cost is that they can give us insights into how the comparative cost of animal draught is likely to change over time in response to exogenous influences and also suggest policy initiatives to reduce costs or increase the overall availability of draught power.

By the time an ox is put to work it represents an investment which is equivalent to the present value of all the feed consumed since it was born plus any other costs involved in keeping it alive, in addition to a portion of its mother's maintenance costs (and, one might add, a small portion of its father's) less the value of any products - milk, hides, manure, meat, etc. - which have been obtained in the process. Bose and Clark suggest that allocating this cost to each of the bullock's working years would be difficult, both conceptually and practically. They propose as an alternative looking at the annual cost of maintaining that herd which is necessary to perpetuate the required number of working bullocks, less the value of any by-products produced. In their model only male animals work, milk is treated as a by-product, and the number of females is that number which is required to replace the adult males who die or are slaughtered. The assumption is that all excess females and unproductive adults are killed off.

Clearly a model such as this is appropriate, at the most, only in parts of Bangladesh. It might, for example, be applicable in Rangpur. In the rest of the country female draught animals play an important part and they must also be taken into account. If the use of females for draught has a significant effect on fertility - as is suggested in Chapter 4 - their use for draught has an opportunity cost, and the model has to be adapted to accommodate this.

The model is based on demographic "stable population" models. They start with a static population and subsequently introduce a modification to allow for an increasing herd size. The life history of the herd is shown in Figure 5.1. In year 0 a total of X_0 calves is born. Of these all the males and the requisite number of females, amounting to X_1, are retained and the remaining $X_0 - X_1$ are

FIGURE 5.1: MODEL OF THE LIFE HISTORY OF A CATTLE HERD



Source: Bose & Clark (1970)

killed or raised for meat. What happens to the remaining animals is of no interest since we are only concerned with the population necessary to sustain the workforce. Of the animals which are kept X_2 survive until the age of T_1, when they are put to work. It is assumed that males and females mature at the same age, although the model could be altered relatively easily to accommodate differences. A total of X_3 animals survive to age T_2 when all that remain are killed off. The survival rate for the first period S_1, is X_2/X_1, and the survival rate for the second period, S_2, is X_3/X_2.

The herd is divided into four groups: males and females in Period 1 of their lives, i.e. young bullocks and young females, and males and females in Period 2, i.e. working bullocks and breeding females. Given the number of births per reproductive female per year and the proportion of these which is male, it is possible to express the number of males and females born each year in terms of the number of reproductive females. If, in addition, the proportion of males and females surviving through Periods 1 and 2 is known, taking account of the proportion of females disposed of at birth, then the number of animals in each of the four categories can be expressed in terms of the number of calves born and, hence, in terms of the number of reproductive females. All that is now known is the number of females which have to be disposed of at birth in order to maintain a stable population. This is easily calculated, since there is only one value of this variable which will allow the number of reproductive females as calculated above to be an identity. The algebra of the calculation appears in the Appendix to this chapter.

5.3: Critical Calving Rate

In Chapter 2 an expression has been derived for the critical calving rate which is necessary for the herd of breeding females to replace itself. This is:

$$\bar{b} = \frac{1}{(1-n)S_1Z_2} \qquad (1)$$

Where

S_1 = survival rate of young females
Z_2 = sum of survival rates of adult females
n = proportion of calves born each year which are male.

The significance of each of the parameters can be seen in an example. One was given in Chapter 2 with rather optimistic mortality assumptions. Consider what happens if only half of the females born survive to adulthood. It is assumed that half the calves are female and that the mortality rate for adult cows is 3% per annum over a reproductive life of eight years. Then

$n = 0.5$
$S_1 = 0.5$
$Z_2 = 7.21$
and $\bar{b} = 55\%$

Unless a calving percentage of 55% can be maintained the herd will decline.

5.4: A Female Draught Model

The Bose and Clark model can be adapted to take account of female draught, provided that the effect on their rates of reproduction is known. A stable cattle population is assumed, which is prevented from rising by the amount of feed available. Farmers attempt to increase their workforce by the use of females, but at the expense of decreased fertility. The question is whether it pays to use females for draught and, if so, under what conditions. What is the optimum proportion of the female population which can be used for draught power?

Bose and Clark effectively assumed a fixed requirement for draught animals (adult males) and calculated the number of adult females and young stock necessary to maintain this number in a stable herd. Given the feed requirement of the different categories, they were then able to calculate the amount of feed necessary to maintain the desired herd of draught animals. Looked at from the opposite point of view, the model gives the size of the draught herd which can be supported by a given amount of feed. The proportions between the different categories of stock are determined by the stable herd assumption, together with mortality and fertility parameters.

In the Appendix to this chapter, the model is modified to take account of the use of females for draught. It is assumed that a proportion, x, of the female herd is used for draught and that this has a depressive effect upon their fertility. The proportions in the herd of the different categories of stock have to be adjusted to take account of this change in overall calving percentage. The bullock equivalent of the draught females is given by the total number of draught females - x times the total number of adult females - multiplied by a factor, k, which gives the bullock equivalent of each. Adding the result to the number of adult males gives the total draught force which is a function of x and the herd parameters (mortality, fertility, consumption requirements, proportion of calves which are male, and bullock equivalence of draught females). The condition can be calculated for this to be a maximum.

It turns out that it is worth using either the entire female herd or none, depending on the value of the herd parameters. In fact, given reasonable assumptions for the herd parameters, it will <u>always</u> pay to use all of the adult females for draught. There is, however, an important proviso, and that is that the reduction in fertility does not reduce the overall calving percentage below the critical value given by (1). Let

b_1 = calving percentage of non-draught adult females
b_2 = calving percentage of draught adult females
Fr = number of adult females
x = proportion of adult females used for draught.

The maximum value which x can take without causing the herd to decline in numbers is given by

$$b_1(1-x)+b_2x=\bar{b} \qquad \text{for } b_1 \geq \bar{b} \geq b_2 \qquad (2)$$

where $\bar{b} = \dfrac{1}{(1-n)S_1Z_2}$

If $b_2 > \bar{b}$ x=1, i.e. all draught females can be used for draught

If $\bar{b} > b_1$ the herd is in decline and the use of females for draught simply hastens it.

An example is set out in Table 5.2. It is assumed that sufficient feed is available to feed 1,000 livestock units. The numbers of adult males and females are shown for fixed values of b_1 and b_2, and for various values of x. Calves are assumed to come to maturity after 4 years and adult animals have a working life of 11 years. Mortality in the first 4 years is 33% (S_1=0.67) and in the remaining 11 years is 29% (Z_2=9.46).

It will be noted that the total workforce continues to increase right from x=0 to x=1. At x=0.615, however, the critical calving rate is reached; beyond this point the increase is achieved at the expense of a progressively faster rate of decline of the herd size. This situation is, of course, unstable and the workforce would decline with the overall herd size. With x less than 0.615 young females would have to be disposed of to preserve a stable population, and the conditions of the Bose and Clark model are maintained. With x greater than 0.615 the female herd does not replace itself and the conditions of the model break down.

TABLE 5.2: MALE AND FEMALE DRAUGHT FORCE UNDER A NUTRITIONAL CONSTRAINT FOR DIFFERENT PROPORTIONS OF CULTIVATING COWS
(b_1=0.5 b_2=0.2 k=0.6 S_1=0.67 Z_2=9.46)

Cultivating Cows as Proportion of Adult Females	Overall Calving Ratio	Adult Males	Adult Females	Bullock Equivalent of Draught Females	Total Draught Force
x	b	B_w	F_r	xkF_r	B_w+xkF_r
0.0	0.50	566	369	0	566
0.2	0.44	544	390	47	591
0.4	0.38	517	429	103	620
0.6	0.32	484	477	172	656
0.615	$\bar{b}$=0.316	481	481	177	658
0.8	0.26	442	536	257	699
1.0	0.20	389	614	368	757

Table 5.2 also serves to illustrate how the calving percentage affects the structure of the stable herd. The same amount of feed can support 566 adult males at a calving percentage of 50%, but only 484 at 32%. A larger proportion of the herd has to consist of reproductive females simply to maintain the herd size.

5.5: The Effect on Milk Production

The above assumes that all other products, meat, milk hides, manure, either have no value or are unchanged in value when more females are used for draught. It is not unreasonable to assume that the value of manure, hides and meat are little changed. Milk, however, is another matter. We can distinguish cases in which milk has value, draught animals have value, or both. It is only the second and third of these which interest us here. The case where milk has little value has already been covered above; Noakhali is an example in Bangladesh. In the case where milk has an appreciable value, i.e. Comilla, the opportunity cost of using females for draught, in terms of the value of milk foregone, has to be considered.

It is assumed that milk production will be reduced as a result of a longer calving interval rather than through a drop in the amount of milk produced per lactation. No doubt, there will be a fall in the amount per lactation, but we do not have an expression for this and it seems reasonable to assume that it will be small compared to the total loss resulting from a less frequent calving interval.

Given the quantity of milk produced by each cow per lactation, and the number of calves born to each cow each year, the quantity of milk per cow per year can be calculated.

Let q = quantity of milk per cow per lactation (seers)
b = number of calves born per year per fertile female

Then calving interval in years $= \frac{1}{b}$

quantity of milk per cow per year $= \frac{q}{\frac{1}{b}} = bq$

Total quantity per year is $M = bqF_r$ (3)

The calculation can be illustrated by using the data in Table 5.2. If x is increased from 0 to 0.615, the calving ratio falls from 0.5 to 0.316, the number of adult females in the herd is increased from 369 to 481, and the total draught force (males plus female-equivalent) increases from 566 to 658. The calving interval lengthens from

$$\frac{1}{0.5} = 2 \text{ years to } \frac{1}{0.316} = 3.16 \text{ years.}$$

If the amount of milk produced by each cow per lactation is 100 seers, then the amount produced per cow per year falls from

$$\frac{100}{2} = 50 \text{ seers to } \frac{100}{3.16} = 31.6 \text{ seers.}$$

Total milk production falls from

$$369 \times 50 = 18{,}450 \text{ seers to } 481 \times 31.6 = 15{,}200 \text{ seers,}$$

a drop of 3,250 seers. The increase in the size of the draught force is 92 bullock-equivalents. Therefore, the cost of each in terms of milk foregone is 35.3 seers.

5.6: The Feed Requirement of Draught Animals

The average amount of feed consumed by each draught animal as recorded by the survey is set out in Table 5.3 by commodity.

TABLE 5.3: FEED CONSUMED BY AN AVERAGE DRAUGHT ANIMAL IN A YEAR

Seers per Livestock Unit (1)

Village	1	2	3	4	5	6	7	8	9 (2)	10 (2)
Straw (3)									1339	
Grass										
Lalee	73.2	75.7	4.7	0.1		0.3			1.8	
Rice Polishings	82.8	0.3	172.9	78.9	23.0	270.8			998.2	380.7
Chaff (4)	10.7	32.1	3.2	117.5	57.1	85.5		0.7	166.3	39.3
Lalee, oilcake & salt		239.1	3.1							6.0
Rice/broken rice	2.7	15.4	0.4		7.9	2.6				
Rice cooking water					89.0				24.5	34.0
Rice Polishings & salt								0.4	191.3	
Oilcake	15.8	17.4	2.7	1.0	57.8	91.6	16.9	10.3	162.5	46.0
Salt	0.9	8.6	1.42						11.5	

Notes:

(1) A female draught animal is assumed to consume .77 of the consumption of an ox
(2) 44 weeks only
(3) Straw is by far the largest part of the diet in terms of bulk but was only imprecisely recorded hence no values are shown, except for village 9
(4) Chaff of wheat, rice and dal.

Other commodities which are also consumed, but with only small quantities recorded are:- water hyacinth, molasses, lentil, paddy thinnings and jackfruit waste.

TABLE 5.4: UNIT COST OF ANIMAL FEED BY VILLAGE — Taka/seer

Village	1	2	3	4	5	6	7	8	9	10
Lalee	0.89	0.48								
Rice polishings			0.55	0.48	0.68	0.72			0.40	0.24
Chaff		0.33		1.21	0.75	1.20			1.47	1.42
Oilcake	1.83	0.87	2.58	2.12	1.64	1.55	2.21	2.07	1.53	1.18
Lalee, oilcake & salt		0.49								
Broken rice					1.55	2.38				
Salt		1.15							0.61	
Rice cooking water									0.40	
Rice polishings & salt									0.40	

Note: Items have only been included if total expenditure for the village exceeds 100 taka.

TABLE 5.5: PERCENTAGE OF FEED CONSUMED BY DRAUGHT ANIMALS WHICH IS PURCHASED — Percent

Village	1	2	3	4	5	6	7	8	9	10
Straw										
Grass										
Lalee	6	38		100						
Rice polishings	5		7	63	25	7			100	100
Chaff	10	32	-	34	97	95		100	100	100
Lalee, oilcake & salt		40	30							100
Rice/broken rice	-				57	46				
Rice cooking water					1				100	100
Rice polishings & salt								100	76	
Oilcake	90	65	100	97	95	98	100	100	100	100
Salt	98	79	98						97	

TABLE 5.6: VALUE OF FEED CONSUMED BY AN AVERAGE DRAUGHT ANIMAL IN A YEAR

Taka per Livestock Unit (1)

Village	1	2	3	4	5	6	7	8	9	10
									(2)	(2)
Straw										
Grass										
Lalee	65.1	36.3	2.5	0.1		0.2			0.9	
Rice Polishings	19.9	0.2	95.0	37.9	15.6	195.0			339.3	91.4
Chaff	3.4	10.6	2.0	142.2	42.8	102.6		0.2	244.5	55.8
Lalee, oilcake & salt		117.2	1.5							3.0
Rice/broken rice	4.6	26.2	0.7		12.2	6.2				
Rice cooking water					35.6				9.8	13.6
Rice polishings& salt									76.5	
Oilcake	28.9	15.1	7.0	2.1	94.8	142.0	37.3	21.3	248.6	55.0
Salt	1.0	9.9							7.0	
TOTAL (excluding straw & grass)	122.9	215.5	110.3	182.3	201.0	446.0	37.3	21.5	926.6	218.8
										269.0

Notes: (1) On the basis of unit costs from Table 5.5
(2) 44 weeks only

The results are very similar to those obtained by Odend'hal (1972) for West Bengal. Grazing is extremely limited. There are no crops grown strictly as fodder crops and most of the feed is a by-product of human consumption. The major constituent of the diet is rice straw (over 75% of the total energetic intake in West Bengal). Unfortunately, in Bangladesh rice straw is only measured when it is traded, and even then the units tend to be vague ones such as piles. Hence, it was impossible for farmers to give any reasonable estimate of the amount of rice straw which they feed to their animals. Also farmers found it difficult to distinguish between the fodder given to draught animals and to others.

In West Bengal Odend'hal found that an adult male consumed 21,688 kcal per day, of which 78.8% was accounted for by rice straw. This amounts to 50 maunds of rice straw per year, given that 1 kg (wet weight) is equivalent to 3,272 kcal. In Western Comilla District Briscoe (1979) estimated the average gross energy intake for 10 bullocks, 20 cows and 18 immatures to be 10,600 kcal per day of which 54% was consumed by 10 bullocks and 10 working cows. This accords exactly with the relative rates of consumption derived by Odend'hal for bullocks, cows and immatures, i.e. 1 : 0.63 : 0.42. On this basis an adult male would consume 16,850 kcal, equivalent - if that were the only item of diet - to 48.5 maunds of rice straw. Briscoe does not tell us what the composition of the diet is. The only one of our villages for which a direct comparison is possible is village 9. In this village 33 maunds of rice straw per livestock unit were recorded in 44 weeks. Considering the difficulty which farmers would have in estimating a maund of rice straw, as well as the problems mentioned above, this provides a reasonable correspondence with Odend'hal and Briscoe.

5.7: The Cost of Feed

Only a very small proportion of the rice straw consumed is traded. Hence, the price is very difficult to estimate; 10 taka per maund is probably not far wrong. Unit costs of other commodities which were bought for consumption by draught animals are shown in Table 5.4. In Table 5.5 can be seen the percentage of feed which is purchased. Strictly speaking, what it shows is the percentage of the amount recorded as fed to draught animals for which price information was also recorded. This table, therefore, serves as a check on the reliability of the data, since for certain commodities, i.e. oilcake and salt, we know that the entire amount must have been purchased. It also shows, in conjunction with Table 5.3, how large the traded quantities were for which prices have been calculated in Table 5.4. No price has been calculated where the total amount was less than 100 taka.

On the basis of these prices, the values of the commodities in Table 5.3 were calculated and are shown in Table 5.6. The overall average is 269 per livestock unit, excluding straw and grass. If, in addition, we assume the consumption of 43 maunds of rice straw at 10 taka per maund, the total cost of animal feed comes to 700 taka per livestock unit. Clearly, both components of this sum should be treated with the greatest caution, particularly the latter. Not only are the quantity of rice straw consumed and its price little more than inspired guesses, but the fact that only a relatively small proportion is traded means that the price is not necessarily a very good proxy for the opportunity cost.

Farmers were only asked about the amounts fed to draught animals. In West Bengal Odend'hal found that adult females consumed 62% of the ration of an adult male and immatures only 42%. Since farmers clearly attempt to feed a more substantial diet to their draught animales, it was assumed for the purpose of the calculations in Table 5.3 that draught females receive more than 62%. The figure used was the one used by Bose and Clark for West Pakistan, i.e. 77%. In fact, only in villages 2, 3 and 4, where a substantial proportion of the draught force is female, does the choice have any other than a very minor significance.

5.8: The Social Cost of Feed

On the grounds that: "Transportation problems combined with presently limited markets make it unlikely that any amount of additional production of milk and meat could be absorbed at the present price", Bose and Clark argue that the appropriate social cost of crop by-products is best measured by their value in alternative uses outside the livestock sector. If the reason for calculating the opportunity cost is to compare it with the cost of a wholesale replacement of draught animals by tractors, we are not dealing with marginal changes. Hence, the rejection of the hire charge and the capital cost type of calculation. In certain areas of Bangladesh, for example Comilla, there is a ready demand for milk, whereas in others, for example Noakhali, it is virtually nil. Even in Comilla, however, a large-scale release of resources to milk production would quickly saturate the market. The major demand for cattle for beef is for the Id festival, and in some parts of the country, for example Munshiganj, fattening stock for this purpose is an important activity. Prime animals can change hands at this time of the year at extremely high prices, which suggests that demand is very inelastic and would quickly be satisfied if feed resources were released.

What then is the opportunity cost of these resources? In an ecosystem as much under pressure as that in Bangladesh a value can be found for everything. The two Noakhali villages provide an extreme example. There, apart from rice straw and a certain amount of grass, the animals get very little other than some purchased oilcake. By-products from the farm, if they are not used for human consumption, can be burnt. There is considerable competition for rice straw to be used as fuel.

Briscoe (1979) has looked in some detail at the energy needs of a village in the Western part of Comilla District. Crop residues provide over 70% of the fuel used by his study population. Cooking efficiency is low and three calories of fuel are required to cook one calorie of food. Each calorie of food also requires one calorie of animal feed. He distinguishes between <u>kher</u>, the tender upper part of the rice stem, which is carried to the house with the harvest, and <u>nara</u> which is left standing in the field. <u>Kher</u> is used mainly for feed, but can be used for fuel or compost, and <u>nara</u> is used mainly for fuel, but can be used for compost and occasionally as feed. On the few occasions on which they are sold <u>kher</u> fetches five times the price of <u>nara</u>.

An interesting aspect of Briscoe's study is the differential use of fuels by different classes and the way this affects the social structure. "Competition for the organic materials produced by the land has become intense; the number of village trials arising from disputes over the ownership of trees and crop residues is large and growing. The marginal social and economic groups are denied access to organic materials on which they previously depended for fuel and are forced to purchase fuel from the market. Given the inflexible requirements for cooking fuel, animals are fed less and are fed inferior fodders (such as water hyacinth), and the amount of organic materials returned to the land is reduced". (p. 633).

The upshot is that the opportunity cost of crop by-products is far from as low as one might suppose. Milling offals have been exported in recent years and this must set a lower limit to their opportunity cost. We have seen that for certain crop residues there is competition for use as fuel. The values in Table 5.4 are maximum values, but it is quite likely that they are not very much greater than the social opportunity costs. Similarly the figures in Table 5.7 can be taken as the maximum values for the particular set of parameters with which they are associated. It hardly needs to be said that the calculations are extremely sensitive to the opportunity cost assumed for rice straw.

5.9: The Opportunity Cost of Animal Draught

It is now possible to put together the various cost components of maintaining the herd necessary to support one working bullock (or female equivalent). Total costs (or benefits) are calculated and divided by the size of the draught force (bullock-equivalent). Using the notation of the Appendix (see also Table 5.2), this is given by:

$$B_W + xkF_r$$

The feed requirement per bullock-equivalent is the most important component and an expression for this is provided by equation (24) in the Appendix:

$$\bar{d} = \frac{A + \frac{B}{b}}{1 + \frac{Cx}{b}}$$

It is also necessary to work out the value of milk, dung, meat, hides, bones, etc., as well as making an estimate of the additional costs, such as veterinary medicine. Looking after the animals, which is often the responsibility of adolescent children, is assumed to have zero social cost.

Dung is probably the easiest to estimate. Odend'hal found that adult males, adult females and immatures produce 1.9 kg, 1.3 kg and 0.9 kg of dry matter, respectively, per day. Briscoe estimates the average dry-dung production to be 1.2 kg per day, that is 1.8 kg, 1.2 kg and 0.8 kg for each of the categories. Thus production of dry-dung per l.u per year is estimated as 660 kg. According to Briscoe, 71% of dung is used for fertiliser and 23% for fuel. For West Bengal Odend'hal considered 70% as a conservative estimate of the quantity used as fuel. Assuming that firewood has twice the thermal efficiency of dry dung[1], and that firewood costs 15 taka per maund[2], the value of dung per l.u per year is 134 taka. Since this is produced by the various categories of animal more or less in proportion to their feed intake, it can simply be deducted from the feed cost.

The total amount of milk produced per year is given by equation (3) of this chapter, that is:

$$M = bqF_r$$

Estimates of q vary considerably. Both Briscoe and Bose and Clark estimate milk production at 50-60 kg per adult female per year. Odend'hal has two estimates which together give a figure of 175 kg per adult female per year. Something closer to the former seems more appropriate. The figure used in this calculation is 120 kg per lactation.

What little information we have on the selling price of animals when they have finished their working life suggests an average of 400 taka per animal. We can only assume that this represents a reasonable estimate of the social value of the meat, hides, bones, hooves, etc. Calculation of the numbers is straightforward. By the definition of Z_2 (see Section 5.3 above), and number of males and females entering period 2 is:

$$\frac{B_w + F_r}{Z_2}$$

If S_2 is defined as the survival rate of animals in period 2, the number available for sale at the end of the period is:

$$\left(\frac{B_w + F_r}{Z_2}\right) S_2$$

The social cost of veterinary care lies mainly in the cost of an appropriate proportion of the Government veterinary service, of which the cattle population are the main beneficiaries. This is taken as 50 taka per livestock unit, which can simply be added to the feed costs.

Housing for the animals is assumed to have zero social cost.

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[1] An alternative would be to use data quoted by Bose and Clark (1970) from Energy Survey of India Committee "Report of the Energy Survey of India Committee", New Delhi, Government Press, 1965. One ton of manure (equivalent to approximately 0.3 tons of dry dung) is equivalent to 9 pounds of nitrogen, 3 pounds of available P_2O_5 and 3 pounds of available K_2O, plus the value of the organic matter. One ton of dry dung is equivalent to 0.4 tons of coal or 0.06 tons (15.8 gallons) of kerosene.

[2] The price of firewood in rural areas is 10 taka to 18 taka per maund (37 kg) according to M. N. Islam, "Strategy for rural energy survey in Bangladesh", paper presented at the Institution of Engineers, Dacca, December, 1976, quoted by Briscoe. One kg of dry dung is taken as equal to 2,130 kcal (Odend'hal, from National Council of Applied Economic Research "Domestic Fuels in Rural India", NCAER, New Delhi, 1965).

The results were calculated for eight different mortality assumptions, the details of which are given in Table 5A.1 in the Appendix to this chapter. They were calculated first for a herd with no draught females, i.e. according to Bose and Clark (Appendix Table 5A.2), and then for herds with draught females on a variety of fertility assumptions (Appendix Table 5A.3). In every case it is assumed that the calving ratio for draught females is 15 percentage points lower than for those which are not used for draught. In Table 5.7 the components are shown for just one set of mortality assumptions, and for two sets of calving percentages - 70% (with 55% for draught females) and 40% (with 25% for draught females).

TABLE 5.7: THE OPPORTUNITY COST OF ONE DRAUGHT OX (OR EQUIVALENT)

	Cost per Ox (No Females) (Taka)		Cost per Working Animal (Taka)	
	$b=.7$	$b=.4$	$b_1=.7$ $b_2=.55$ $b=.626$	$b_1=.4$ $b_2=.25$ $b=.325$
			$x=.5$	$x=.53$
Straw	694	817	620	676
Other Feed	436	513	389	424
Veterinary Care	81	95	72	76
Housing	-	-	-	-
Herding	-	-	-	-
LESS				
Dung	216	255	193	211
Milk	151	151	131	115
Salvage value	44	54	37	43
TOTAL	799	965	720	807

Given the mortality assumptions used ($S_1=.67$, $S_2=.71$, $Z_1=3.464$, $Z_2=9.46$), the critical calving ratio is 0.32. For the lower pair of calving percentages shown in the table, the critical proportion of females used for draught (beyond which point the herd size declines) is given by x=0.53. For the higher pair the proportion is taken as x=0.5, that is the average from Table 4.1.

Although these calculations are rather tedious to carry out, the effort can be justified from a number of points of view. They allow:

a) calculation at the most fundamental level of the opportunity cost of the resources used to support each draught animal;
b) analysis of the cost of draught power when the herd is constrained from growing by shortage of feed;
c) calculation of the opportunity cost of using females for draught;
d) examination of the possible effects of policies which will affect herd parameters such as: (i) improved nutrition,
(ii) reduced mortality,
(iii) improved fertility.

The evidence of Chapter 2 suggests that, if anything, herd sizes in Bangladesh are decreasing rather than increasing. It is not unreasonable that what prevents them from rising is the availability of adequate nutrition. Thus models which are based on perfect competition are rendered suspect. Owners of the resources which produce crop residues are in a monopoly position. It is interesting to compare the cost derived in this section with the revenue from hiring out animals (including the opportunity cost of using them on one's own land).

From Table 6.3 it can be seen that in Noakhali and Comilla each acre absorbs some 20 pair-days. Given a density of 0.2 pairs per acre, the total working year of an ox-pair is some 100 days. Hire charges range from an average of 9 taka per pair-day in Rangpur to 29 taka per pair-day in Munshiganj, i.e. a total of 900 taka to 2,900 taka. Considering that the hire charge normally includes the services of a ploughman, it seems clear that in Rangpur hirers-out of draught animals are not covering their average cost. The ploughman's wage is, however, likely to be a fixed cost - he will be a family member or permanent labourer - and hence the marginal cost will be near zero. The overall average for all the villages is a little over 20 taka per pair-day, which gives annual earnings of about 2,000 taka. From this must be subtracted the opportunity cost of the ploughman's time. His alternative opportunities are likely to be limited and hence this cannot be high. Given also that the figures calculated in this section are a maximum estimate, it would appear that in certain areas owners of draught animals are able to extract a monopolistic rent.

The calculations above are admittedly very crude. They do, however, serve to demonstrate what the components are of the cost of animal draught power. The actual valuations attached to them are frequently a matter of judgement and errors get compounded. What stands out is the very great importance which attaches to the nutritional aspect of the cost calculation and the implicit constraint which feed availability places upon increased cropping.

APPENDIX TO CHAPTER 5.

1. Bose and Clark Model

Let

P = total cattle population required
By = young bullocks
Bw = working bullocks
Fy = young females
Fr = reproductive females
b = number of births per reproductive female per year
n = probability of a male calf being born
Bb = number of males born in a year
0 to T_1-1 (in completed years) = young age of males and females
T_1 to T_2-1 (in completed years) = working age of bullocks and reproductive age of females
T_2 (in completed years) = age of being killed off
S_1 = survival rate of males and females from 0 to age T_1 years
S_2 = survival rate of males and females from T_1 to age T_2 years
Z_1 = sum of survival rates in period 1
Z_2 = sum of survival rates in period 2

i.e.

$$Z_1 = \sum_{t=0}^{T_1-1} S_1^{(t/T_1)} \qquad (1)$$

$$Z_2 = \sum_{t=T_1}^{T_2-1} S_2^{(t-T_1)/(T_2-T_1)} \qquad (2)$$

Then

$$Bb = Frnb \qquad (3)$$

$$By = BbZ_1 \qquad (4)$$

$$Bw = BbS_1Z_2 \qquad (5)$$

$$Fr = \frac{Bb}{nb} = \frac{Bw}{nbS_1Z_2} \qquad (6)$$

$$By = Bw.\frac{Z_1}{S_1Z_2} \qquad (7)$$

Since working ages and survival rates for males and females are the same:

$$\frac{Fy}{Fr} = \frac{By}{Bw}$$

$$Fy = \frac{By}{Bw} \cdot \frac{Bw}{nbS_1Z_2}$$

$$= Bw \cdot \frac{1}{nbS_1Z_2} \cdot \frac{Z_1}{S_1Z_2} \qquad (8)$$

If dbw, dfr, dfy and dby are the feed requirements (in livestock units) of working bullocks, reproductive females, young females and young males, respectively, the total feed requirement is:-

$$Bwdbw+Bydby+Frdfr+Fydfy$$

And the feed requirement, $\bar{d}$, of the herd necessary to maintain one working bullock is:

$$\bar{d} = dgw+\frac{By}{Bw}dby+\frac{Fr}{Bw}dfr+\frac{Fy}{Bw}dfy \qquad (9)$$

From (6), (7) and (8):

$$\bar{d} = dbw+\frac{Z_1}{S_1Z_2}dby+\frac{1}{nbS_1Z_2} \cdot dfr+\frac{1}{nbS_1Z_2} \cdot \frac{Z_1}{S_1Z_2} \cdot dfy \qquad (10)$$

Write for later convenience:

$$A = dbw+\frac{Z_1}{S_1Z_2} \cdot dby \qquad (11)$$

$$B = \frac{1}{n\ S_1Z_2}\left(dfr+\frac{Z_1}{S_1Z_2} \cdot dfy\right) \qquad (12)$$

i.e. $$\bar{d} = A+\frac{B}{b} \qquad (13)$$

The expressions for Z_1 and Z_2 in equations (1) and (2) are calculated on the assumption of a stable herd size. If the bullock population is growing at a compound rate g, all other expressions are unaltered but Z_1 and Z_2 are modified as follows:-

$$Z_1 = \sum_{t=0}^{T_1-1} S_1^{(t/T_1)} e^{-(t+0.5)g} \qquad (14)$$

$$Z_2 = \sum_{t=T_1}^{T_2-1} S_2^{(t-T_1)/(T_2-T_1)} e^{-(t+0.5)g} \qquad (15)$$

Bose and Clark do not mention the need for bulls to service the reproductive females in their herd. This is simply disposed of if we consider bulls to be members of the working population. An alternative would be to relate the bull population to the adult female population by a coefficient, say 1 : 30, and add them to the population in equations (9) and (10).

2. Female Draught Model

Let
x = proportion of fertile females used for draught
b_1 = number of births per non-cultivating female per year
b_2 = number of births per cultivating female per year
K = total feed available
k = male equivalence of each draught female
D = total male and female draught force

$$b = (1-x)b_1+xb_2 \qquad (16)$$

From (13)

$$K = \bar{d}.Bw = \left\{ A+\frac{B}{b} \right\} Bw$$

i.e.
$$Bw = \frac{K}{A+\frac{B}{b}} \qquad (17)$$

From (6)

$$Fr = \frac{K}{\left(A+\frac{B}{b}\right)} \cdot \frac{1}{nbS_1Z_2} \qquad (18)$$

$$D = Bw+xkFr$$

$$= \frac{K}{\left(A+\frac{B}{b}\right)}\left(1+\frac{xk}{nbS_1Z_2}\right) \quad \text{from (17) and (18)}$$

For convenience write

$$C = \frac{k}{nS_1Z_2} \qquad (19)$$

i.e.
$$D = \frac{K}{\left(A+\frac{B}{b}\right)}\left(1+\frac{xC}{b}\right) \qquad (20)$$

$$= \frac{K(xC+b)}{(Ab+B)}$$

$$= \frac{K(xC+(1-x)b_1+xb_2)}{A(1-x)b_1+Axb_2+B} \quad \text{from (16)}$$

$$= \frac{K(b_1+x(C-b_1+b_2))}{(Ab_1+B)+Ax(b_2-b_1)}$$

Differentiate w.r.t. x

$$\frac{dD}{dx} = K\left(\frac{(((Ab_1+B)+Ax(b_2-b_1))(C-b_1+b_2)-(b_1+x(C-b_1+b_2))A(b_2-b_1))}{(Ab+B)^2}\right)$$

$$= K\left(\frac{((Ab_1+B)(C-b_1+b_2)-Ab_1(b_2-b_1)+Ax(b_2-b_1)((C-b_1+b_2)-(C-b_1+b_2)))}{(Ab+B)^2}\right)$$

$$= K\left(\frac{C(Ab_1+B)+(b_2-b_1)(Ab_1+B-Ab_1)}{(Ab+B)^2}\right)$$

$$= K\left(\frac{BC+ACb_1+B(b_2-b_1)}{(Ab+B)^2}\right) \qquad (21)$$

The condition for a maximum is thus independent of x. It will be worth either using the entire adult female herd for draught or none at all depending only on the values of b_1, b_2, k, n and the mortality assumptions, and provided also that b is above the critical value given by equation (4) of the chapter.

A maximum at x=0 will be given by $\frac{dD}{dx}$ negative and at x=1 by $\frac{dD}{dx}$ positive.

Thus: Max. at x=0 if $b_1-b_2 > C\left(1+\frac{Ab_1}{B}\right)$ (22)

Max. at x=1 if $b_1-b_2 < C\left(1+\frac{Ab_1}{B}\right)$ (23)

The implications are now explored on a variety of mortality assumptions. First, however, the relative consumption rates of different categories of animal are considered. The rates used by Bose and Clark were dbw = 1.00, dby = 0.77, dfr = 0.77, and dfy = 0.74. More realistic for Bangladesh would appear to be the rates observed by Odend'hal in West Bengal where the composition of the diet is almost identical to that in Bangladesh, viz. dbw = 1.00, dfr = 0.62, dfy = 0.42, dby = 0.42 (Odend'hal, 1972).

Since it is assumed that the herd is constrained from growing by the availability of feed, g is taken to be zero. Bose and Clark assume a working life of 8 years and adopt two assumptions about the age of maturity, three years and four years. They take as survival rates .8 for period 1 irrespective of whether it is three or four years, and .9 for period 2. Both of these would appear to be too high for Bangladesh; the latter assumes an adult mortality of only 1.3% per annum. They also assume an extremely high calving percentage of 80%.

The mortality assumptions used here for Bangladesh are, on the whole more pessimistic. There are two basic sets. The first takes mortality in the first year to be 10% and in each subsequent year 3% (assumptions 1-4 in Table 5A.1). The second is inferred from the herd profile in Figure 2.1 for the first three years of a calf's life and is taken to be 3% thereafter (assumptions 5-8). S_1 and S_2 are then calculated for $T_1 = 3$ or 4 and $T_2 = 12$ or 15. There are thus altogether eight assumptions. Values of the various variables are shown in Table 5A.1, together with the critical calving rate $\bar{b}$ and values of $C\left(\frac{1+Ab_1}{B}\right)$ for $b_1 = .4$ and $b_1 = .8$.

TABLE 5A.1: VALUE OF CONSUMPTION VARIABLES FOR VARIOUS HERD PARAMETERS (n=.5 and k=.6)

Assumption	S_1	S_2	T_1	T_2	Z_1	Z_2	A	B	C	$C\left(\frac{1+Ab_1}{B}\right)$ $b_1=.4$	$b_1=.8$	$\bar{b}$
1	.85	.76	3	12	2.845	7.991	1.176	0.234	0.177	0.533	0.889	0.29
2	.82	.78	4	12	3.719	7.194	1.265	0.300	0.203	0.545	0.888	0.34
3	.85	.69	3	15	2.845	10.181	1.138	0.175	0.139	0.501	0.862	0.23
4	.82	.71	4	15	3.719	9.460	1.201	0.200	0.155	0.527	0.900	0.26
5	.69	.76	3	12	2.665	7.991	1.203	0.299	0.218	0.569	0.920	0.36
6	.67	.78	4	12	3.464	7.194	1.302	0.382	0.249	0.588	0.928	0.41
7	.69	.69	3	15	2.665	10.181	1.159	0.222	0.171	0.528	0.885	0.28
8	.67	.71	4	15	3.464	9.460	1.230	0.268	0.189	0.536	0.883	0.32

It will readily be seen that for every one of the 16 values shown in the table the inequality at (22) could only be satisfied by negative values of b_2. The implication is that the optimum value of x is 1, i.e. all cows would be used for draught, for all values of b_2 over a wide range of values of b_1. It needs to be stressed, however, that this would be at the expense of a declining herd size if the calving ratio falls below the critical value $\bar{b}$. Hence, if we wish to preserve a stable herd, the optimum value of x is given by

$$b_1(1-\bar{x})+b_2\bar{x}=\frac{1}{(1-n)S_1Z_2}$$

for all the mortality assumptions in Table 5A.1.

Thus corresponding to (13) are the following:-

1.) $$\bar{d}=\frac{A+\frac{B}{b}}{1+\frac{Cx}{b}} \qquad \begin{array}{ll} \text{any } x & b_2 > \bar{b} \\ x \le \bar{x} & b_1 > \bar{b} > b_2 \end{array} \qquad (24)$$

2.) A stable herd is impossible $x > \bar{x}$ $b_1 > \bar{b} > b_2$

$b_2 < \bar{b}$

3. The Opportunity Cost of Draught Animals

On the basis of the mortality assumptions of Table 5A.1, the opportunity cost of a working bullock was calculated based on the data in section 5.8. The results are shown for b=.4, b=.5, b=.6 and b=.7 in Table 5A.2.

In Table 5A.3 the calculations are modified to take account of the use of females for draught. In each case it is assumed that there is a difference of 15 percentage points in the calving percentages of draught and non-draught females. It is also assumed that where $b_2 > \bar{b}$ half the adult females are used for draught (the average from Table 4.1). Where $b_1 > \bar{b} > b_2$ it is assumed that x takes the critical value $\bar{x}$.

TABLE 5A.2: THE OPPORTUNITY COST OF A DRAUGHT OX (NO WORKING FEMALES) Taka

Assumption	b=.4	b=.5	b=.6	b=.7
1	877	811	766	734
2	999	914	857	818
3	817	766	732	708
4	875	816	778	751
5	955	869	813	772
6	-	995	922	870
7	873	807	765	734
8	965	888	836	799

Note: Figures shown are the annual cost of maintaining the herd required to support one working ox.

TABLE 5A.3: THE OPPORTUNITY COST OF A DRAUGHT BULLOCK EQUIVALENT (WITH WORKING FEMALES) $b_1 - b_2 = .15$ (by assumption)

		$\bar{d} = A + \frac{B}{\bar{b}} \Big/ 1 + \frac{Cx}{\bar{b}}$								Cost (Taka)					
		$b_2 > \bar{b}$, x=.5 (by assumption)				$b_1 > \bar{b} > b_2$, $x = \bar{x}$				$b_2 > \bar{b}$, x = .5				$b_1 > \bar{b} > b_2$, $x = \bar{x}$	
						$\bar{x}$		$\bar{x}$							
	b_1	.4	.5	.6	.7		.4		.5	.4	.5	.6	.7	.4	.5
	b_2	.25	.35	.45	.55		.25		.35	.25	.35	.45	.55	.25	.35
	b	.325	.425	.525	.626										
Assumption	$\bar{b}$														
1	.29		1.429	1.388	1.358	.73	1.357				703	677	658	676	
2	.34		1.591	1.539	1.501	.40	1.751				783	749	725	876	
3	.23	1.381	1.332	1.299	1.276					712	681	659	645		
4	.26		1.414	1.379	1.353	.93	1.258				719	696	679	645	
5	.36			1.468	1.432	.27	1.797	.93	1.291			712	686	900	633
6	.41			1.641	1.595			.60	1.628			796	765		801
7	.28		1.400	1.360	1.332	.80	1.296				710	684	666	665	
8	.32		1.522	1.475	1.441	.53	1.571				774	743	720	807	

CHAPTER 6: SHARECROPPING AND DRAUGHT POWER

6.1: Introduction

Sharecropping has long presented a paradox to economists. The traditional neo-classical approach is illustrated in Figure 6.1. The upper curve represents the value of the product arising from increasing amounts of an input (conventionally, labour) applied to a particular parcel of land. The lower curve is that portion which would be retained by a tenant under a sharecropping agreement. The slope of OT represents the price of the input (or, in the case of family labour, its opportunity cost in terms of foregone alternative earnings). It can readily be seen that a maximising tenant will produce a total net product of PM by applying OM of labour, and provide a share to the landlord of PQ. The maximising owner-cultivator (or a tenant on a fixed rental) will produce SN by applying ON of labour. Hence sharecropping has been characterised as inefficient. The share tenant under-supplies inputs and overall production is less. "Policy responses have ranged from limited tenurial reforms which seek merely to adjust the terms of the sharecropping contract to alleviate economic disincentives (typically unsuccessfully) to land-to-the-tiller policy models which posit an end to the landlord-tenant dyad through the abolition of landlordism". (Herring, 1978, p.225).

The paradox arises from the fact that is it impossible to redraw Figure 6.1, either by adjusting the share which the landlord receives or by changing the price of the input, in such a manner that the landlord would not be better off cultivating the land himself or letting it on a fixed rental. It becomes very difficult to explain the widespread prevalence of sharecropping in countries with social structures and agricultural economies as disparate as those of the USA, Europe, China and Bangladesh. Given that empirical evidence of the alleged inefficiency has been hard to find, it is not surprising that economists have sought a more satisfactory model to explain the existence of sharecropping. Share tenancies "have been a fruitful source of error and confusion to writers from Adam Smith down to the present" (Newbery, 1976).

6.2: Theories of Sharecropping

In recent times the debate was opened by Johnson who noted that "though admittedly inadequate, the available evidence indicates that the crop-share contract yields at least as much, if not more, rent per acre than does the cash lease on comparable farms", (Johnson, 1950, p.111). He concluded that the landlord must seek to enforce a minimum level of tenant input, i.e. to push PM up to SN, as shown in Figure 6.2. "Three techniques are available to the landlord for enforcing the desired intensity of cultivation. The first is to enter into a lease contract that specifies in detail what the tenant is required to do. A second is to share in the payment of expenses to the same extent as in the sharing of the output. The third is to grant only a short term lease, which makes possible a periodic review of the performance of the tenant". (Johnson, 1950, p. 111).

FIGURE 6.1.

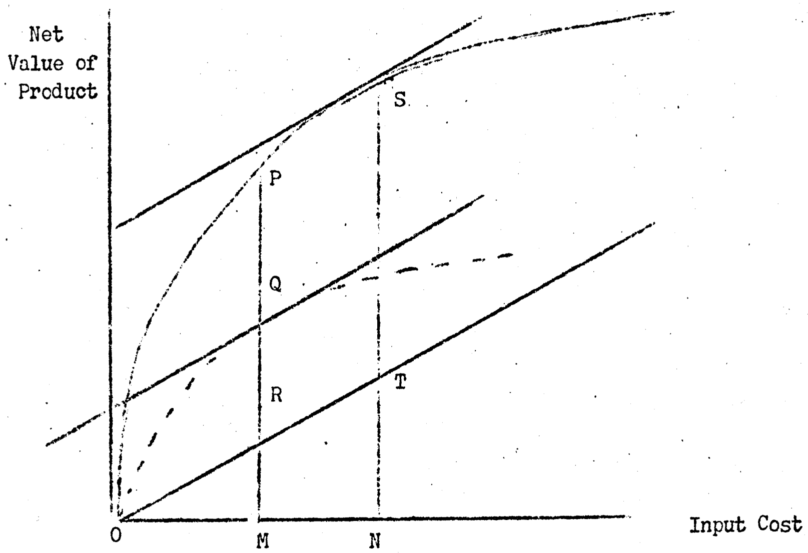
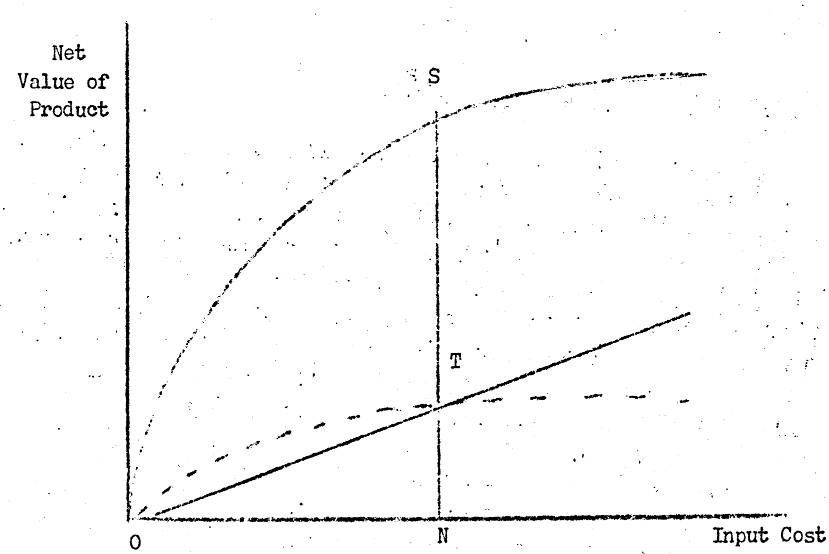


FIGURE 6.2.



Because of its relevance to the USA, Johnson focused his attention on the last of these. He argued that with a short-term lease sharecroppers would be aware that landlords have the alternative of renting their land for a cash rent. Consequently, the tenant would plan to produce an average output per acre which would provide a return to the landlord, if yields are average, equal to the possible cash rent.

Cheung (1969) developed a model in which the tenancy contract specifies a minimum level of inputs. There is a perfectly elastic supply of prospective tenants who have the alternative of certain employment as labourers at an exogenously determined wage rate. The contract also specifies the share proportion and this and the minimum level of inputs are set at an equilibrium level determined endogenously within the model. Cheung argues that a landlord will not allow one tenant to cultivate all his land if, by parcelling it out to a number of tenants, he can achieve a higher total rent. If we assume diminishing marginal productivity of land, the landlord can, by restricting the size of holding, ensure that the tenants are operating on only the highest portion of their marginal product curves. This is shown in Figure 6.3. Of course, as the area assigned to each tenant becomes smaller, the share proportion must be adjusted, if the tenant is to achieve his alternative level of earnings. Hence, the area per tenant is also determined endogenously. In fact, Cheung shows that under his assumptions, equilibrium will settle at a level which causes inputs to be supplied in the same amount as they would be under an owner-cultivator or fixed rental regime. There is then nothing to choose for either landlord or tenant between the different regimes. Thus in Figure 6.2 a minimum level of inputs ON will be specified causing production to be at S, the same as for self-cultivation by the landlord. The return to the tenant's inputs is TN, as if he sold them on the market, and the landlord's return is ST, the same as under self-cultivation or a fixed rental.

Newbery (1976) has generalised Cheung's analysis, while retaining the neo-classical assumptions, to cover risk-averse actors (risk-averse in the rather restricted sense that they maximise the expected utility of income which varies with a known frequency as a result of environmental risks). Labour and land can be hired at perfectly certain rates and in unlimited amounts with zero transaction and supervision costs. There are constant returns to scale and each agent has a known initial endowment of land and/or labour valued at the factor prices. Newbery first demonstrates that an equilibrium (if it exists) with only wage and fixed rent contracts will be production efficient, with marginal products equated in all farms. He then goes on to show that under share tenancy the only mutually acceptable share contract is the efficient contract which has a share rental which divides output amongst landowners and labour owners in the same ratio as for wage and fixed rent contracts. At any level other than this the tenant or the landlord would be better off by shifting to a wage contract or a fixed rental.

In trying to account for why sharecropping should be favoured in some places rather than others, the literature has tended to stress the risk-sharing aspects of sharecropping where it is favoured and its high transaction costs (negotiating contracts and supervising their fulfilment) where it is not. Cheung himself maintained that

FIGURE 6.3.

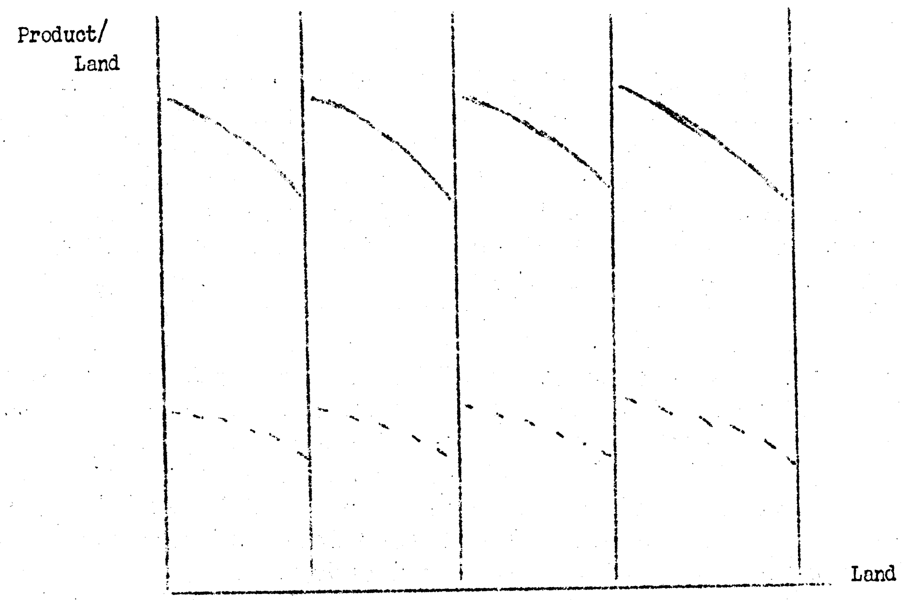
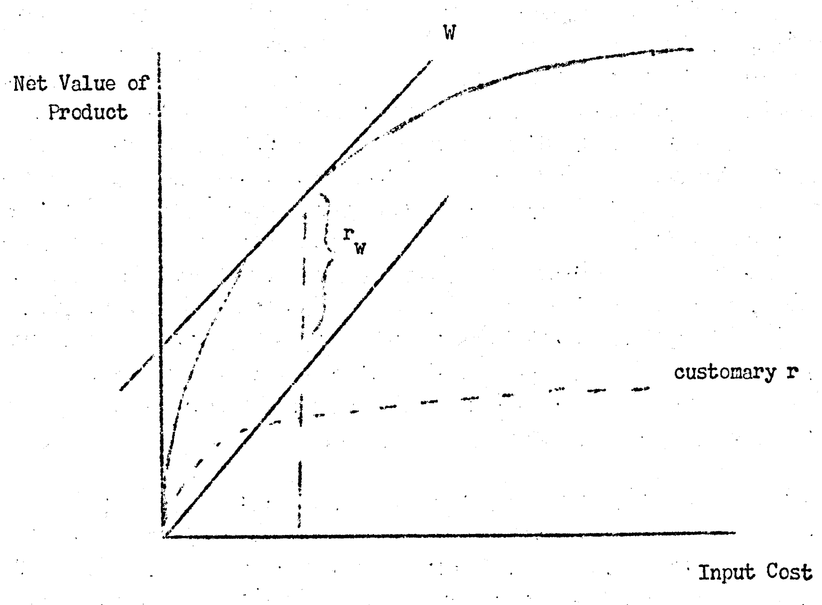


FIGURE 6.4.



share contracts would cost more to enforce. However, his model required landlords to specify and police a particular level of inputs, whereas Newbery (1976) has shown that Johnson's condition of an average required level of output leads to efficiency. This could be much cheaper. Having disposed of the risk-sharing aspect - as he sees it - Newbery has to seek other arguments to account for the prevalence of sharecropping by relaxing some of the neo-classical assumptions. He shows that three assumptions are crucial, and that if any of these are relaxed, models can be constructed in which sharecropping confers additional benefits on tenants and landlords compared with wage and fixed rent contracts. These assumptions are (i) certainty in the labour market, (ii) enforceable wage and fixed rent contracts which are costless, and (iii) constant returns to scale.

A critic of what he calls the "New School" is Bell, who refers to the alternative school as "Marshallian".[1] He comments that the assumption of a homogeneous and elastic supply of labour at an exogenously determined wage is misleading if land and labour are not the sole factors. As regards the labour market itself he makes the point that the relationship between agricultural labourer and tenant status may be asymmetric. A tenant can become a labourer but a landless labourer cannot suddenly opt to become a tenant if he possesses neither the requisite skills nor capital, i.e. draught power. The tenant has a supervisory role over hired labour, - he has a vital managerial role for which he will seek a suitable reward. If hired labour is paid at the time the work is performed, the tenant will also require a premium over the wage labour rate to compensate him for delayed payment, i.e. at harvest time.

6.3: Sharecropping and Animal Draught in Bihar

From the point of view of this study, Bell's most interesting point is the stress he lays upon draught power. In the area he studied in Eastern India he observed that the elasticity of substitution between labour and draught animals is probably very low, there being no historical tradition of human traction (or digging) for land preparation except for small-scale vegetable cultivation, together with a broad social disdain for such methods. He adds that an <u>ex ante</u> "choice of technique" approach would yield the same result. Hence the importance of the tenant having an assured source of draught power.

---

[1] Bell quotes Marshall as follows:-

> "If the landlord cultivates the amount (of capital) freely and in his own interest, and can bargain with his tenant as to the amount of labour he applies, it can be proved geometrically that he will so adjust it as to force the tenant to cultivate the land just as intensively as he would under the English tenure (fixed rent): and his share will then be the same as under it".

(Marshall - "Principles of Economics", p.536 n[2]).

The Cheungian analysis, he says, could be extended to cover draught power inputs, simply by having the landlord specify a minimum level of draught inputs as well as a minimum level of labour intensity, except that

a) hired draught is only a very small fraction of total draught inputs - in marked contrast to labour;
b) owning at least one pair of bullocks is a sine qua non for obtaining a lease and this is the distinguishing characteristic of tenants owning no land of their own. Of the 25 pure share-sharecropper and 31 owner/sharecropper households sampled, only one had no draught animals and he operated the smallest holding.

Bell adds that these findings are supported by interviews in which tenants said that, though there is a daily rate for the hire of bullock team season by season, in practice it is extremely difficult to hire. Even where hire is possible, a sharecropper rarely has enough liquidity to enter into this transaction. No cultivator could afford to rely on the hire market, nor, indirectly, could any landlord. Hence, there is a likelihood that tenants would own some land, since ownership of land and ownership of livestock are very highly correlated.

In order to test for a relationship between the ownership of draught power and sharecropping, Bell calculated a simple linear regression of the value of the tenant's draught stock on the area he cultivates. The relationship was strong for both pure sharecroppers and owner/sharecroppers, particularly so for the latter. He got a better fit for the owner/sharecropper group and suggests that perhaps this is due to the greater ease of matching draught power and area operated when some land is owned and leasing land is only a partial adjustment (see next paragraph). Comparing these results with similar results for labour, Bell comes to the conclusion that it appears that draught power endowment is a more powerful determinant of the tenant's ability to lease in land than his family labour supply. Certainly this is so for the owner/sharecropper group.

Bell sees the essential mechanism whereby those with "excess" draught power realise its economic potential as the leasing in of land rather than the hiring out of draught power. He argues that transaction costs are lower in the land market than in the draught power market, if only because transactions are less frequent. Of course, the fact that the draught hire market is so under-developed in the area of Eastern India being studied increases the transaction costs. Small farmers have higher endowments of stock per acre owned than large farmers, hence they lease land in from the latter. Small farmers have an advantage in stock rearing where there are common rights and animal minding can be undertaken by a child.[1]

[1]Both Newbery and Bell have published a number of articles on this topic. What is presented here does justice neither to the scope nor sophistication of their arguments.

6.4: Theory in Relation to Sharecropping in Bangladesh

The central point of the debate about sharecropping has been to attempt to explain why in certain circumstances share rents are favoured, and in other, fixed rents. In Bangladesh rental agreements are overwhelmingly of the sharecropping variety; hence this aspect of the debate is only of direct interest insofar as it enables the prediction of circumstances which might lead to a change to fixed rents. It has already been remarked that the literature has tended to seek an explanation in differences in supervision costs and in different attitudes to risk-sharing. Thus, in regard to the former, it has been argued that in the Georgia cotton belt in the United States the costs of enforcing labour services by wage labour led to the leasing of plots to tenants. The co-existence of share and fixed rents is explained as follows: "on a small holding the cost of supervising a few share tenants might be negligible, but as the size of the plantation increased, the cost of supervision also increased, and the gains from the adoption of the fixed rental, which required much less supervision, became larger", (Higgs, 1974, p. 475, quoted by Newbery). In the circumstances of Bangladesh, where holdings are small - and, if anything, likely to get smaller - it seems improbable that there would be a shift to fixed rental tenancies for this reason.

From the point of view of this study the crucial aspect is the relationship between land tenure and draught power. In contrast to Purnea District studied by Bell, in Bangladesh there appears to be a ready market in animal draught power (and, in a very few cases such as Munshiganj, also for mechanical draught power).

The number of sampled farmers in each village who own no draught animals (male or female) can be seen in Table 6.1. In all ten villages 37% of the farmers own no draught animals (28% of the heavily mechanised Munshiganj villagers are excluded). Since it is the smaller farmers who tend not to own draught animals, the proportion of the total land area operated by farmers without draught animals is lower, i.e. 23% for the whole sample and 14% excluding Munshiganj.

However, many farmers who own draught animals also hire them in. Thus, the total number of pair-days hired in is a larger proportion of total pair-days than might at first be thought. In fact, the amount of animal draught power used per acre is actually greater on the land of those who are entirely dependent on hiring in than on those who are self-sufficient. An indication of the working of the market in draught power can be seen in Table 4.18 of Gill (1981), where hire charges together with the amount of hiring are set out week by week. Although prices vary from one location to another, it will be seen that they are reasonably stable from one week to another.

None of the models is entirely satisfactory for trying to relate sharecropping and the market in draught power in Bangladesh. In Cheung's model the share proportion 'r' is determined by market forces and is equal, in equilibrium, to the elasticity of output with respect to land, which is another way of saying that the rent per acre of land is equal to the marginal product of land. In Bangladesh, however, as in many parts of the world, the share proportion

TABLE 6.1: OWNERSHIP OF DRAUGHT ANIMALS BY SIZE OF HOLDING AND CATEGORY OF TENURE.

No. of D. A. (1)	LANDLORD/CULTIVATORS(2) Number of farmers cultivating				OWNER/CULTIVATORS Number of farmers cultivating				OWNER/SHARECROPPERS(3) Number of farmers cultivating			
	0-2ac	2-4ac	4+ac	Mean Area (Decimals)	0-2ac	2-4ac	4+ac	Mean Area (Decimals)	0-2ac	2-4ac	4+ac	Mean Area (Decimals)
RANGPUR												
Village 1												
0	-	-	1	659	-	-	-	-	1	2	1	301
1	-	-	-	-	-	-	-	-	1	-	-	-
2	-	2	5	695	-	1	5	576	1	7	5	438
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	1	1246	-	-	-	-	-	1	1	529
5	-	-	-	-	-	-	1	1183	-	-	-	-
BOGRA												
Village 2												
0	-	1	-	238	1	1	-	139	2	2	1	286
1	-	-	-	-	-	-	-	-	1	3	2	349
2	-	-	-	-	-	-	5	513	5	6	6	362
DACCA												
Village 3												
0	1	-	-	50	4	-	-	101	1	-	-	64
1	-	-	-	-	1	-	-	100	-	-	1	591
2	-	-	-	-	3	3	4	342	-	5	3	351
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	1	711	-	2	4	582	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	1	474	-	-	2	824	-	-	-	-
Village 4												
0	-	-	-	-	2	1	-	131	-	1	-	349
1	-	-	-	-	-	1	1	450	-	3	-	288
2	-	-	-	-	2	2	1	277	3	6	7	373
3	-	-	-	-	-	-	1	812	-	-	1	590
4	-	-	-	-	-	-	1	1083	-	-	3	1395
COMILLA												
Village 5												
0	1	-	-	112	7	1	-	124	3	1	1	348
1	-	-	-	-	-	-	1	415	2	2	1	519
2	-	-	-	-	5	4	1	234	1	2	1	323
3	-	-	-	-	-	-	-	-	1	-	-	143
4	-	-	-	-	-	-	-	-	-	-	1	411
Village 6												
0	2	-	-	123	4	2	-	151	4	2	-	185
1	1	-	-	80	2	2	-	190	3	-	1	220
2	-	1	3	728	2	4	2	272	1	-	-	176
NOAKHALI												
Village 7												
0	3	1	1	213	7	3	1	241	2	1	-	192
1	-	-	-	-	-	-	-	-	-	1	2	448
2	-	-	1	623	-	-	2	1164	1	1	6	832
3	-	1	-	317	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	2	2532
Village 8												
0	3	3	-	170	4	1	-	148	1	-	-	132
1	-	1	-	362	-	-	-	-	1	1	-	217
2	-	-	2	991	1	1	-	273	1	-	12	780
3	-	-	-	-	-	-	-	-	-	1	2	427
4	-	-	-	-	-	-	-	-	-	-	1	740

...... continued

TABLE 6.1 continued

No. of D. A. (1)	LANDLORD/CULTIVATORS (2) Number of farmers cultivating 0-2ac	2-4ac	4+ac	Mean Area (Decimals)	OWNER/CULTIVATORS Number of farmers Cultivating 0-2ac	2-4ac	4+ac	Mean Area (Decimals)	OWNER/SHARECROPPERS (3) Number of farmers cultivating 0-2ac	2-4ac	4+ac	Mean Area (Decimals)
MUNSHIGANJ												
Village 9												
0	-	-	-	-	3	2	-	181	10	9	1	247
1	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	1	-	-	168	2	4	3	312
3	-	-	-	-	-	1	-	328	-	-	-	-
Village 10												
0	-	-	-	-	5	3	4	279	4	6	5	446
1	-	-	-	-	-	-	-	-	1	-	-	136
2	-	-	-	-	2	-	-	169	1	-	2	461
3	-	-	-	-	-	-	1	491	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	2	785

NOTES: (1) D. A. = Draught Animals.
Both male and female draught animals are included

(2) Net sharecroppers out of 10 decimals or more in one or more seasons

(3) Net sharecroppers in of 10 decimals or more in one or more seasons.
The entire sample includes only 5 sharecroppers who own less than 5 decimals.

is determined by custom. There are minor variations in arrangements for sharing the cost of inputs (excluding labour and draught power), but the basic share ratio is fixed at 50% (see page). In Figure 6.4 for a given price of inputs W, the (Cheungian) equilibrium level of r is r_W. If the customary level of r is greater than this, the owners of inputs will be better off selling their inputs at W than in sharecropping land. Similarly, if the customary level of r is less than r_W, the owners of land will be better off cultivating it themselves and hiring inputs at price W. The problem is not solved by allowing W to be determined endogenously. Although we can, in this diagram, find a value of W which will make r_W equal to the customary r as in Figure 6.2, the total amounts of inputs and land remain unchanged - as do the production functions - and there is no reason to suppose that this represents a general equilibrium.

If one assumes imperfections in the labour market, as Bell does, so that tenants under-value labour expended working for themselves (even on sharecropped plots), then a solution can be found. However, Bell seems to reject this, since he sets out to demonstrate empirically that even if landlords worked to enforce intensity of cultivation, they were apparently unable to do so. He must look elsewhere for an explanation of why landlords are prepared to give out their land for sharecropping.

6.5: Studies of Sharecropping in Bangladesh

Zaman (1972) has studied sharecropping specifically in relation to Bangladesh. He points out that sharecropping is practised on 16 per cent of the total cultivated area, but that 25 to 50 per cent of farmers are involved, depending upon the region. Landless sharecroppers are rare in Bangladesh; the majority are generally small farmers who sharecrop land in order to utilise the excess family labour that cannot be employed elsewhere. In most cases, landowners rent their land to new sharecroppers every year to prevent them from developing an occupancy right. In the areas he studied - Thakurgaon and Phulpur - the operations of sharecroppers are closely supervised by the landowners.

Sharecropping in Bangladesh is explained by Zaman in terms of imperfections in the labour market. Whereas landlords who have to hire labour will employ it to the point where the marginal value product equals the wage rate, sharecroppers and small owner-cultivators, relying on family labour, will employ labour up to the limit imposed by the production possibility curve. Cropping intensity is higher for sharecropping than owner-farming in both Thakurgaon and Phulpur. Considerations of per acre availability of family labour and the impression the author got from talking to farmers, lent support to the argument that "the institution of sharecropping has developed in those places because, due to capital-rationing and managerial bottlenecks, every landowner could not cultivate each piece of his land as intensively as is potentially profitable, and own land of some other cultivators were not sufficient to make an efficient use of their fixed resources such as draft animals, machinery and implements and family labor" (p.13). This is the only reference that Zaman makes to draught power. "The results of the survey ...

do not provide any conclusive proof of significant yield differences in the owner operated and sharecropped lands" (p.8). Unfortunately, he does not publish any significance tests.

Zaman also found that sharecropping arrangements, as such, do not influence the acceptance of modern inputs such as fertiliser and irrigation water; landlords often share the costs of such modern inputs in the same ratio as output is shared. However, he lays great stress on the lack of access to institutional credit for sharecroppers and concludes that this, rather than the form of land tenure, is likely to inhibit the use of modern inputs.

A further study of sharecropping in Bangladesh was undertaken by Jabber (1977) in Mymensingh, Rangpur and Dinajpur. One hundred farms were selected purposively in each of the three regions with a view to measuring resource use efficiency of different tenure classes. This was done through the use of Cobb-Douglas functions. The analysis indicated that owner-operators were more efficient in allocating resources compared to those in tenure.

Jabbar comments on Khan's suggestion (Khan, 1972) that larger farmers resort to sharecropping because they do not have enough capital (internal surplus) to finance their farm businesses. Jabbar remarks that larger farmers have access to institutional credit for this purpose, if necessary. He maintains that some farmers do have an adequate surplus but prefer to invest it in land accumulation or non-farm business.

6.6: A Model of Sharecropping in Relation to Draught

The following is an attempt to construct a model with features from both the "Marshallian" and "New Schools". It depends on three assumptions:

a) the Johnsonian condition is fulfilled that tenants provide a minimum return to their landlords;
b) tenants value labour expended in cultivating for themselves (even on sharecropped plots) at a lower price than the wage rate;
c) the customary landlord share is not greater than the equilibrium rent.

The first assumption is not difficult to support. Leases in Bangladesh are under constant review and tenants are well aware that if they do not provide an adequate return to their landlord, i.e. equal to what he could get by cultivating himself, they will quickly find themselves replaced. Newbery (1976) has shown that the Johnsonian condition is sufficient to ensure efficiency. However, in a share contract context there is no assurance that the customary landlord share can be equated to the equilibrium share.

Imperfections in the labour market have been stressed by Bell (1977) "When land ownership is highly concentrated, it is probable that the labour market will be oligopsonistic. Moreover, as the demand for labour shows strong seasonal variations and depends on the state of nature, the notion that employment offers are available in any amount at a perfectly certain wage is difficult to accept. These factors, together with the transaction costs of entering the labour market and a psychic aversion to working for others, will combine to make the reservation price of family labour somewhat lower than the going wage for a range of family labour input levels (however the wage is determined). One consequence of this has received much attention: the inverse relationship between farm size and output per acre, commonly attributed to higher labour intensities on smaller holdings". (p.321).

In Figure 6.5, OA and OB represent the response curves of production - net of all other inputs - to draught input for the tenant and landlord, respectively. Since the tenant uses labour more intensively, he is on a higher production function. OC represents that part of production which is retained by the tenant: conventionally 50% of OA. If the price of draught power is exogenously given by the line OX, then the landlord producing for himself, would use ON of draught power and his net return over the cost of draught power would be LM. If the tenant is required to produce a return at least equal to this, he would use OU of draught power, providing a return of RS=LM to the landlord and a tenant's "producer surplus" equal to ST.

No equilibrium will be possible if the customary landlord share is greater than the equilibrium rent in the absence of sharecropping, since it will not be in the landlord's interest to lease his land. Hence, the third assumption above. Nor will there be equilibrium if the customary landlord share is so small that S is to the right of X, the point where the input price line meets the tenant's share curve. Any divergence between the customary share and the equilibrium rental has to be offset by an excess of tenant productivity over landlord productivity. This is consistent with the lack of success which has been achieved in various parts of the world by legislative attempts to reduce the landlord's share.

If the customary landlord's share is only just less than the equilibrium rent, a relatively small difference in productivty will push the point at which the landlord produces. This has an important implication, the model does not require greater intensity of use by the tenant of <u>all</u> tenant-supplied inputs; one could be sufficient. Indeed, the roles of labour and draught power in the model could be reversed, provided that the latter is owned by the tenant and that his opportunity cost for self-cultivation is less than the market price. Transaction costs for draught power include travelling to and from the hirer's plots, although this need not necessarily be greater than travelling to the owner's own plots. As Gill points out (see Volume I) travelling costs relative to working time could be higher for mechanised draught power. An important factor causing a difference between the opportunity cost of self-cultivation and the hire price for both labour and draught power could be the cost of credit.

Whatever the relationship between the customary share and the equilibrium rent, the point at which the tenant produces will be to the right of that which the landlord produces, if the difference in productivity is sufficiently large. The greater the difference in productivity the more the chance there is of an equilibrium point for

FIGURE 6.5.

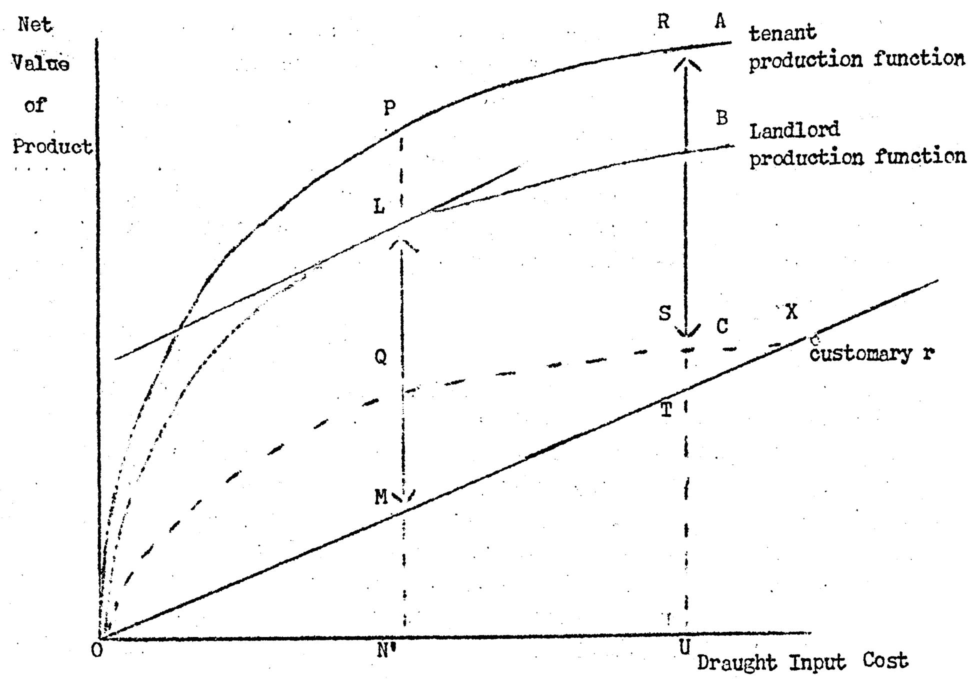
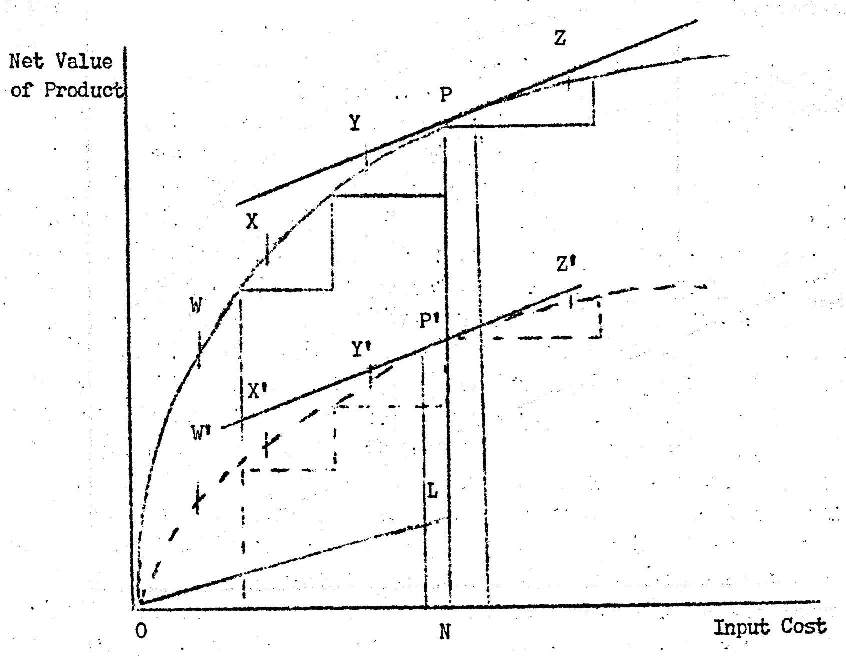


FIGURE 6.6.



the tenant (i.e. the point at which the price line is tangent to his retained share curve) producing a return which will satisfy the landlord.

6.7: Sharecropping and Indivisible Inputs

All the above assumes that draught power is an infinitely divisible input. Let us now try to combine the analysis in chapter 3, where the lumpy nature of draught power was recognised, with the analysis of sharecropping. At first sight it might be thought that, since a single equilibrium relates to a range of possible prices of a factor when that factor is in lumpy supply, then an analysis which takes account of this lumpiness might, on occasion at least, provide a solution to the sharecropping problem. Unfortunately, this proves not to be the case.

Let us dispose, first of all, of the case where the demand for draught power is perfectly inelastic, i.e. it is used in a fixed quantity per acre. The landlord will only receive his 'required return' if the tenant uses labour more intensively, i.e. has a higher production function relative to draught power. This is illustrated in Figure 6.5. Both landlord and tenant use ON of draught power per acre and the landlord requires a return of LM. This is only possible if the tenant's production function, OA, is sufficiently far above OB, the landlord's production function, for PQ to equal LM. The only way that this is possible is if the tenant under-values his labour compared to the market wage. In fact, we are back at the Bell case.

The result is the same if we consider a more divisible, but still lumpy, technology. In Figure 3.6 we saw that production would be at X or Y depending on whether the tangent to the underlying production function was to the left or right of P (the point at which a line parallel to XY is tangent to the underlying production function). A similar point Q could be determined between Y and Z. We might call P and Q 'indifference points', because at these points the farmer is indifferent between production at the point above or point below. At any price between the tangents at P and Q production will take place at Y. In Figure 6.6 to each of the 'indifference points' W, X, Y, Z on the underlying production function, there correspond 'indifferent points' W', X', Y', Z' on the underlying tenant's share curve. It is easy to conceive of a case where the price of an input is such that a line parallel to it will meet the underlying production function between Y and Z and another parallel line will meet the underlying tenant's share curve between Y' and Z'. For both landlord and tenant, then, the quantity of the input used, ON, will be the same and production will be PN, with PP' being the landlord's share. However, the landlord could get a better return, PL, by cultivating himself. So, we still do not have a solution to the sharecropper problem. We have to come back, therefore, to the situation in which the tenant cultivates more intensively than the landlord, and the landlord requires from the tenant a 'required return'. In discussing this above (Section 6.6) we saw that in certain circumstances the 'required return' might also produce an optimum for the tenant. This is also the case for an indivisible technology with, of course, only a number of discrete levels of input to choose from.

6.8: Empirical Results

It would seem, then, that sharecropping depends for its existence - at least where the share rent is decided by custom - on imperfections in at least one market for inputs which are provided by and, in some cases, owned by the tenant. Hence, it is to be expected that, if the imperfections were reduced, sharecropping would tend to give way to fixed rental tenancies.

The "Marshallian" model of sharecropping, as expounded by Bell, predicts lower output and reduced use of inputs on sharecropped land. In Table 6.3 mean inputs and outputs are set out for three categories of tenure for the sample villages in Noakhali and Comilla. In Table 6.4, the owned and sharecropped plots of owner-sharecroppers are compared. In both cases, owners have a higher cropping intensity than either landlord/cultivators or owner/sharecroppers (non-significant in the case of Comilla). Sharecropped plots are also cultivated less intensively than the owned plots of owner/sharecroppers. These results need treating with a certain amount of caution, however, since it is not completely clear that all plots sharecropped for less than a full year have been eliminated from the analysis. These would inevitably depress the cropping intensity for sharecropped land.

The results for Noakhali follow quite closely those obtained for Purnea District, Bihar, by Bell. He found that cropping intensity, the use of intermediates (Rs. per acre), the cost of hired labour (Rs. per acre) and yield (Rs. per acre) were significantly higher for the owned plots of owner/sharecroppers than they were for their sharecropped plots or the plots of pure sharecroppers (Bell, 1977, p.332). We did not have data for landlords or owners, nor did he have data for animal-draught input or family labour. In Noakhali there is a significant difference (1% level) between the family labour input per cultivated acre and also per cropped acre of owner/sharecroppers and landlord/cultivators. There is also a significant difference between the family labour input per cultivated acre between sharecropped and owned plots of owner/sharecroppers. However, the significance disappears for cropped area. In fact, the differences in input levels between sharecropped and owned plots of owner/sharecroppers can largely be ascribed to differences in cropping intensity. The only significant differences per cropped acre either for Noakhali or Comills are in the amount spent on fertiliser and these results are opposite for the two districts.

Yield differences in Noakhali are largely dependent on the use of improved varieties. Virtually no fertiliser is used on traditional varieties. In the aman season, when only traditional varieties are used, there is no difference in the yield of owned and sharecropped plots of owner/sharecroppers. The proportion of the aus acreage planted to improved varieties averaged over the two aus seasons covered by the survey are:

Landlord/cultivators		90%
Owners		65%
Owner/sharecroppers -	Owned plots	60%
	Sharecropped plots	36%.

TABLE 6.2: AREA CULTIVATED BY CATEGORY OF TENURE AND VILLAGE

Village	Ave. Area Cultivated (Decimals)	LANDLORD/CULTIVATORS(1)		OWNER/CULTIVATORS		OWNERS/SHARECROPPERS(2)				% of land share-cropped
		No.	Ave. Area Cultivated (Decimals)	No.	Ave. Area Cultivated (Decimals)	No.	Ave. Area Cultivated (Decimals)	Ave. Area Share-cropped	Ave.% of cultivated area share-cropped	
Rangpur 1	542	9	752	7	664	20 (3)	404	128	31.6	13.1
Bogra 2	355	1	239	7	406	28 (3)	346	148	43.1	32.5
Dacca 3	386	3	412	23	398	10	349	92	26.4	6.6
4	459	-	-	12	381	24	498	252	48.9	36.6
Comilla 5	279	7	112			16 (4)	386	160	41.5	25.5
6	257	7	463	18	213	11	197	127	64.4	15.1
Noakhali 7	573	7	287	13	383	16 (3)	852	420	49.2	32.6
8	488	9	374	7	184	20	646	346	53.5	39.4
Munshiganj 9	254	-	-	7	200	29	267	109	47.4	34.6
10	388	-	-	15	279	21	466	104	31.1	15.6

(1) Net sharecroppers out of 10 decimals or more in one or more seasons

(2) Net sharecroppers in of 10 decimals or more in one or more seasons

(3) Includes one pure sharecropper (owning 5 decimals or less)

(4) Includes two pure sharecroppers (owning 5 decimals or less)

TABLE 6.3: MEAN INPUTS AND OUTPUTS OF LANDLORDS, OWNERS AND SHARECROPPERS

(Figures in parentheses are standard errors)

	n	Cropping Intensity (%)	Fertiliser (taka per cultivated acre)	Hired Labour (taka per cultivated acre)	Aus Yield (maunds per acre)	Amon Yield (maunds per acre)	Owned Draught Animal Pair-days per cultivated acre	Total Draught Animal Pair-days per cultivated acre	Family Labour Days per cultivated acre	Total Labour Days per cultivated acre
COMILLA DISTRICT										
Landlord/ Cultivators	8	136 (10.7)	95 (22)	370 (80)	20.3 (6.8)	38.6 (1.1)	7.7 (1.6)	11.3 (1.2)	13.4 (5.1)	33.9 (5.7)
Owners	39	155 (3.9)	139 (20)	360 (52)	23.0 (8.9)	39.3 (1.2)	15.8 (1.8)	21.4 (2.0)	28.7 (2.4)	43.5 (2.4)
Sharecropper /Owners	25	141 (3.4)	176 (27)	402 (76)	23.5 (7.3)	40.6 (1.9)	12.1 (1.6)	20.5 (1.9)	21.3 (1.5)	36.6 (3.6)
NOAKHALI DISTRICT										
Landlord/ Cultivator	16	162 (12.9)	83 (19)	368 (60)	32.0 (3.7)	19.6 (1.4)	6.0 (2.3)	17.6 (3.4)	19.3 (4.5)	57.2 (5.9)
Owners	18	196 (10.3)	122 (46)	434 (75)	28.9 (1.8)	18.4 (1.0)	5.7 (2.8)	21.8 (2.4)	27.5 (5.7)	66.1 (6.1)
Sharecropper /Owners	38	166 (7,3)	37 (6)	185 (24)	26.3 (1.9)	16.5 (0.7)	15.9 (2.1)	18.9 (1.8)	32.8 (3.0)	49.6 (3.5)

TABLE 6.4: MEAN INPUTS AND OUTPUTS OF SHARECROPPERS ON OWNED AND SHARECROPPED PLOTS

(Figures in parentheses are standard errors)

COMILLA DISTRICT										
Owned plots	158	146 (4.5)	100 (15)	345 (40)	25.2 (1.8)	38.7 (3.0)	16.6 (1.5)	23.4 (2.1)	26.8 (2.0)	39.4 (2.7)
Sharecropped plots	107	129 (4.4)	153 (22)	361 (60)	20.7 (1.9)	41.5 (3.2)	12.8 (2.0)	23.6 (3.6)	23.2 (3.1)	39.5 (6.3)
NOAKHALI DISTRICT										
Owned plots	197	185 (4.6)	59 (7)	187 (14)	30.6 (1.5)	16.5 (0.4)	27.6 (2.3)	32.7 (2.4)	44.8 (3.0)	56.8 (3.2)
Share-cropped plots	178	143 (4.1)	27 (5)	173 (45)	26.7 (2.4)	16.6 (0.6)	22.9 (1.9)	23.9 (1.9)	31.5 (2.1)	43.7 (4.3)

For each of the categories the proportion was relatively constant over the two seasons, except for sharecropped plots, where the proportion unaccountably increased from 21% to 51%. The aus yields shown are for the first of the two aus seasons, since in Noakhali there was virtually a complete crop failure in the second season due to drought. In fact, those who planted traditional varieties got a crop, whereas those who planted improved varieties got none. The question arises as to why landlords who use improved varieties themselves are prepared to sharecrop their land to tenants who do not.

In Comilla cropping intensities are in a similar relationship to those in Noakhali, as are yields, although landlords get the lowest yields rather than the highest. The aus yield on owned plots of sharecroppers is significantly different (at 5% level) from the yield on sharecropped plots, but aman yields are much the same. In contrast to Noakhali, sharecropped plots absorb significantly more fertiliser per cultivated acre and also more hired labour (not significant). In both Comilla and Noakhali more family labour is applied to owned plots of sharecroppers than to sharecropped plots, although the difference is much less marked (non-significant) in Comilla than in Noakhali and on a cropped area basis neither is significant.

Jabbar's study also found heterogeneity between his districts. This is demonstrated in the following table showing cropping intensities:-

	Rangpur		Dinajpur		Mymensingh	
	n	Cropping Intensity %	n	Cropping Intensity %	n	Cropping Intensity %
Part-operator (Landlord/ Cultivator)	15	195	46	107	5	145
Owner-operator (Owner/ Cultivator)	42	178	18	88	72	160
Part-tenant (Owner/ Sharecropper)	43	167	30	96	23	186
Tenant (Pure Sharecropper)		-	6	115		-
	100		100		100	

In general, differences between areas are more marked than differences within areas. In terms of value of output per cropped acre the ranking in each of the three villages was the same, i.e. from highest to lowest: part-operator, part-tenant, owner-operator. However, because of differences in cropping intensity, the value of output per cultivated acre gave a different ranking. Part-tenants (owner/sharecroppers) were highest in Mymensingh (13% above average), lowest in Rangpur (5% below average), and took third place out of four (7% below average) after pure tenants in Dinajpur. In each case part-tenants had the lowest input of casual labour per cropped acre, although differences were small, except in Mymensingh. Significance tests are not given.

It is the relationship between draught power and land tenures which is the particular interest of this study. Some of the data from Table 6.1 have been rewritten in Table 6.5. Only in Comilla and Munshiganj does the proportion of sharecropping households without draught animals exceed 20%, and Munshiganj is clearly a special case (see Volume I of this Report). In the remaining villages almost half the sharecropping households without draught animals cultivate less than two acres. Since all own some land of their own, it seems probable that the majority of this 50% fall into James' category of 'welfare tenants'. The data from these six villages in Rangpur, Bogra, Dacca and Noakhali lend strong support to the notion of ownership of draught animals as a basic qualification for acceptance as a 'commercial' sharecropper. It needs to be stressed that the conventional view of sharecroppers and small farmers being synonomous is far from the case in Bangladesh, as can be seen from Table 6.2.

Jabbar's results are also relevant. In Mymensingh only 6% and in Dinajpur only 1% of all households were without draught animals. The results which he obtained from Rangpur are compared with the results for Rangpur from Table 6.5. (Below Table 6.5).

It is not surprising that Noakhali demonstrates a highly significant difference between the owned animal draught input of owner/sharecroppers on the one hand and of owners and landlord/cultivators on the other, whether on a per cultivated or per cropped acre basis. The <u>total</u> draught input per cropped acre - both owned and hired or exchanged - is very much the same for each of the three categories. The difference in pair-days per cropped acre of owned animals between sharecropped and owned plots of owner/sharecroppers is not significant, although it is per cultivated acre. In these two villages landlord/cultivators and owners hire or exchange 7.2 and 8.2 pair-days per cropped acre, respectively, compared to only 1.8 pair-days for owner/sharecroppers.

In Comilla the difference in owned or total pair-days per acre (cropped or cultivated) between owners and owner/sharecroppers is not significant. The draught inputs of landlords are much less but since the sample included only eight of them little inference can be drawn. This also is consistent with the data in Table 6.5.

6.9: Conclusions

It is tempting to speculate that in Munshiganj the nexus between draught cattle ownership and acceptability as a sharecropper has been broken by the advent of power tillers, and that in Comilla the co-operative hire service which existed for some 15 years has had the same effect. While this might be plausible for the power tiller owning village in Munshiganj, it cannot be true for the other village which has only very recently had access to hired tillers. Certainly, sharecroppers in this village have not been using a hire service sufficiently long to give them confidence to disinvest in draught animals, particularly if landlords see ownership of draught power as a <u>sine qua non</u>.

TABLE 6.5: PERCENTAGE OF HOUSEHOLDS WITHOUT DRAUGHT ANIMALS AND DRAUGHT ANIMALS PER HOUSEHOLD BY CATEGORY OF TENURE

		Landlord/Cultivator			Owner/Cultivator			Owner/Sharecropper			Total		
		n/m	% without draught animals	Ave. No. of draught animals per household	n/m	% without draught animals	Ave. No. of draught animals per household	n/m	% without draught animals	Ave. No. of draught animals per household	n/m	% without draught animals	Ave. No. of draught animals per household
Rangpur	1	1/9	11	2.0	0/7	0	2.4	4/20	20	1.3	5/36	14	1.9
Bogra	2	1/1	100	0.0	2/7	29	1.4	5/28	18	1.4	8/36	22	1.4
Dacca	3	1/3	33	3.3	4/23	17	2.5	1/10	10	1.7	6/36	17	2.3
	4	0/0			3/12	25	1.6	1/24	4	2.1	4/36	11	1.9
Comilla	5	1/1	100	0.0	8/19	42	1.1	5/16	31	1.1	14/36	39	1.1
	6	2/7	29	1.2	6/18	33	1.1	6/11	55	0.5	14/36	39	1.0
Noakhali	7	5/7	71	0.7	11/13	85	0.3	3/16	19	1.7	19/36	53	1.0
	8	6/9	67	0.6	5/7	71	0.6	1/20	5	1.7	12/36	33	1.4
Munshiganj	9	0/0			5/7	71	0.7	20/29	69	0.6	25/36	69	0.6
	10	0/0			12/15	80	0.5	15/21	71	0.7	27/36	75	0.6

JABBER/TABLE 6.5.

	n/m	% without draught animals	Ave. No.	n/m	% without draught animals	Ave. No.	n/m	% without draught animals	Ave. No.	n/m	% without draught animals	Ave. No.
Jabber	1/15	7	2.0	10/42	24	2.3	5/43	12	1.7	16/100	16	2.0
Table 6.5	1/9	11	2.0	0/7	0	2.4	4/20	20	1.8	5/36	14	1.9

n= number of households without draught animals
m = total number of households.

A simpler explanation might be sought in the size of landholding. Where landholdings are small the draught animals' population has to be spread over a larger number of households. There is a very close relationship between the average number of draught animals per household in each village and the total number of households without draught animals. A further factor of importance is the amount of land available to support each animal. It can be seen in Chapter 5 how dependent farmers are on crop residues for maintaining their livestock. Where there is pressure of both human and livestock populations on the land, then not only will the land per household and per draught animal be low, but also the number of draught animals per household since the human population is more capable of expansion than the livestock population. A combination of these two factors - draught animals per household and acres per draught animal - is crucial, since both tend to reduce the probability of finding potential sharecroppers with excess draught. This dual criterion splits the villages into two groups; villages 5, 6 and 9 fall into the lower group, and villages 1, 2, 3, 4, 7 and 8 into the higher group. Village 10 is omitted because of the power tillers.

What the above suggests is that the model of sharecropping as a means for trading the excess land of landlords and the excess draught power of tenants breaks down as land pressure increases. There is no sign that sharecropping is disappearing in these circumstances; the average area cultivated in each village and the percentage of land which is sharecropped are completely uncorrelated. Perhaps sharecropping has a vestigial function in allowing sufficient redistribution of land to avoid social disruption.

CHAPTER 7: SUMMARY AND CONCLUSIONS

7.1: The Availability of Draught Power

Livestock statistics in Bangladesh - as in many developing countries - leave much to be desired. Estimation has been made particularly difficult as a result of the large, but unknown, number of animals which were lost as a result of war and natural disasters in the early 1970s. Estimates of the total herd size range from 17.9m to 29m, and there is similar variation in estimates of the number of draught animals. On the basis of an assumption of a particular draught requirement per acre, estimates usually show a shortage of draught power for the country as a whole. The availability of machine power is very limited.

In this study an attempt is made to examine the availability of animal draught at both a community and an individual level. The data suggest that in only one of the villages surveyed (in Dacca District) is availability better than one pair of draught animals to 5 acres (Table 4.1). Apart from Munshiganj - and probably not even there - the supply of machine power in no way affects the availability of animal draught. In general, in those villages with a greater total availability, the skewness of the distribution is less.

Profiles of the age-sex structure of the cattle population in each of the ten villages were drawn. All of them exhibited some degree of top-heaviness. For the pooled data the majority of male animals were 8-10 years old and females a little younger, giving a peaked mushroom shape to the profile. A possible explanation for the shape of the profiles lies in the sequence of catastropic events referred to above. It is known that many livestock were killed in the War of Independence and also by the cyclone and tidal bore of 1970, although no very reliable estimate of the actual numbers is available. It is also probable that there was a serious reduction in fertility during the drought which followed this period. It is, unfortunately, impossible to estimate mortalities from the profiles, at least for the reverse sections.

It may be that the profiles are not representative. If, for example, there is a tendency for sampled farmers to buy in their adult animals rather than breeding them themselves, the number of young stock would be under-estimated. Except for the Bogra village, this seems unlikely. So, if the profiles are representative of the underlying populations, an implication is that a cyclical element is built into future population changes. The number of potential replacements in all but the youngest and oldest cohorts is less than the number of reproductive females they are to replace. For a constant calving percentage, the number of male and female calves produced will fluctuate with the size of the breeding herd.

A further implication is that the number of draught animals will continue to fall for some considerable time to come. There are two tendencies contributing to this. First, there are fewer replacements alive to take the place of the ageing draught population; for example, the number of males in the age-group 3-7 is less than half that in the age-group 7-11. Secondly, there will be fewer calves produced as the number of reproductive females falls. In effect, the cycle is a very long one.

Calving percentages can probably be derived from the data with greater accuracy than mortality figures. We know the number of calves born during the period of the survey and also the number of females of reproductive age on each of the farms during this period. The ratio of calves to cows is very low in all the villages except one (Table 4.3). This is probably due to a very high calf mortality rather than a long calving interval. It seems likely that in certain areas, at least, herd productivity is so low that the breeding herd is not replacing itself, i.e. calves are being produced at less than the critical calving rate. A concomitant is, of course, a declining number of draught animals.

7.2: The Demand for Draught Power

The pressure for mechanisation in Bangladesh arises from a belief that there is a shortage of draught power, particularly at the aus-amon turn-around. What, however, is meant by a shortage of draught power? Is it appropriate to think in terms of a fixed draught power requirement, or is the marginal productivity of draught power more meaningful? In order to discuss this it is necessary to consider indivisibilities in the supply of draught power. Two concepts of indivisibility are relevant: the indivisibility of capital items and indivisibility of the services provided by these capital items.

It is the former which has received attention. The problem is seen as residing in the fact that agricultural machines are too big to be used economically by a single farmer. Responses have either been technological, i.e. to design smaller machines, or institutional, i.e. schemes for multi-farm use. A technological response is not really an answer in Bangladesh; farms are so small that even the smallest tractors have to be used on more than one farm. In any case, it is impossible to separate technological and institutional factors. However, smaller machines might provide a partial solution, since they can be spread over fewer farms than a large one, and hence are easier to manage.

Even draught animals are a lumpy investment. For many small farmers in Bangladesh even one pair of draught animals is an over-investment if they are not able to hire out. There is, in fact, a well developed hire market in animal draught. The service provided by the draught animals (or machines) is lumpy as well as the capital item itself. The implication of this is that a particular farmer's demand function for services of a particular type of draught power will be stepped. Demand will be perfectly inelastic within certain price bands. The lumpier the services provided, the broader the bands will be. It is this concept which reconciles the notions of fixed draught power requirement and marginal productivity of draught power.

In considering whether or not a farmer's draught availability is adequate to meet his demand, it is necessary to take into account the lumpy nature of the technology. Just as demand is a stepped function, so is supply. It is not the year-round availability of draught animals which is limiting but the availability at peak periods. A possible approach is to calculate whether a farmer has draught power available for one, two, three, etc. passes during the crucial aus-aman turn-around. The maximum number of farmers owning draught power adequate for three passes during this season is approximately 30% in Dacca, Comilla and Bogra. In other areas it is considerably less.

7.3: The Use of Cows for Draught

The low productivity of the herds sampled has been commented on. A likely contributory factor is the use of females as draught animals. In all the areas surveyed females were used for draught although the extent of their use varied from area to area. Very few female draught animals were used in Rangpur, whereas in Bogra virtually all draught power was provided by females.

It was not possible to attribute each calf uniquely to its mother, since in many cases there was more than one adult female on the farm. A categorisation could be made, however, into those farms where all cows were used for draught, and those where some were and some were not. The number of cows per farm was usually very small and the last category was not large. Thus it was possible to calculate a cow:calf ratio for farms where all cows are used for draught and those where none are. There was a significant difference between the two ratios, indicating a drop of some 15% between the calving percentage of non-draught females and those used for draught.

The implication of this drop was examined in Chapter 5. A model was developed to assess the opportunity cost of using females for draught. A stable population was assumed and the structure of the herd necessary to maintain one draught ox equivalent calculated, given age-specific mortalities, the calving intervals for draught and non-draught females, and the proportion of the female herd used for draught. It was found that an optimum was independent of the proportion of the female herd used for draught. Under a range of mortality assumptions, it was profitable to use all of the females in the herd for draught purposes, assuming a difference of 15 percentage points between calving rates for draught and non-draught cows. This only holds true, of course, provided that the overall calving percentage is not reduced below the critical minimum level for survival of the herd.

The opportunity cost of female draught was also calculated in terms of lost milk production. It was assumed that the amount per lactation was unaltered by the use of cows for draught and that any reduction was the result of less frequent lactations. The cost resulting from lost milk production appears to be rather small compared to the value of adding an additional draught animal to the herd.

7.4: <u>The Cost of Animal Draught</u>

In Bangladesh growth of the herd is constrained by the availability of feed. Hence, ownership of the means of nutrition confers upon the owners of such resources a degree of monopoly power. Thus, models for assessing the cost of animal draught which rely upon the assumption of perfect competition are rendered suspect.

In this study use has been made of a model which was developed for Pakistan. The model calculates the structure of the herd necessary to support one draught animal. All products other than draught power are treated as by-products. The value of the model is that it focuses attention on the nutritional constraint. It can also be developed to take account of the use of females for draught.

The model is a stable population model which assumes that any females surplus to the requirement to replace the herd of reproductive females are disposed of at birth. A fixed working life is assumed for both males and females and any surviving beyond this are slaughtered. Given a set of mortality coefficients for young and old stock and a calving percentage for both males and female calves, the number of replacement young stock and of reproductive females can be calculated as a proportion of the number of adult males of working age.

During the survey detailed records were kept of the composition and quantity of feedstuffs consumed. The diet consists largely of rice straw plus some oil-cake and a variety of crop residues. Details were also recorded of the cost of any of these products which were purchased. On the face of it the opportunity cost of these commodities would appear to be low. However, all have alternative uses, including particularly use as fuel. Unfortunately, it is rice straw which is most difficult to estimate, both as regards its cost and also the quantities consumed. The opportunity cost which is calculated is very sensitive to the value of these two variables. Calculation of the opportunity cost is completed by working out the feed and other costs of maintaining each of the different categories in the herd necessary to maintain one draught animal, including, of course, that animal itself. From this is subtracted the value of any by-products, particularly dung, which has rather a high value, and milk.

The model is extended to the case where females are used for draught females. It is assumed that there is a nutritional constraint on the herd and that females are used for draught because of a shortage of males. In this model, therefore, there are no surplus females. The farmer attempts to maximise the number of ox equivalents in his herd (draught females are considered as being equal only to a fraction of an ox) subject to the nutritional constraint. The result is, in fact, independent of the proportion of females used for draught.

Over a wide range of mortality assumptions, it would appear that the cost of each ox-equivalent is less in herds with draught females than in those without. There is, however, one important proviso, and that is that the calving percentage must not be allowed to fall below the critical level.

7.5: Sharecropping and Draught Power

In the second part of this volume, from his work in Noakhali, James has stressed the importance of the link between sharecropping and draught power. In this part the analysis is extended to the other areas and the economics of the link are explored by reference to the theory of sharecropping.

Sharecropping has been typified as 'inefficient' since theory suggests that share tenants will under-supply inputs and produce less than under either fixed lease tenancies or self-cultivation by the landlord with hired labour. Neo-classical theory cannot explain why a landlord sharecrops out his land since he could earn more by self-cultivation or fixed rental. The usual explanation for the choice of one form rather than another is that there is a trade-off between the higher transaction costs of one and the greater riskiness of the other.

A well-known model developed by Cheung depends on the assumptions that landlords require a particular standard of performance from their tenants, with a required level of inputs, and that the share proportion is agreed by negotiation between each individual landlord and tenant. In the case of Bangladesh the first of these assumptions appears very realistic, but the second does not. The share proportion is fixed by convention rather than by the market. Bell has pointed to imperfections in the markets for tenant-supplied inputs, i.e. labour and draught power. If a tenant is prepared to accept a lower marginal return from working land on his own behalf than from hiring out either his labour or his animals, he may well supply inputs in sufficient quantities to satisfy the landlord. In Bihar, Bell found ownership of draught animals to be a sine qua non for acceptance as a share tenant. The hire market for animal draught was virtually non-existent.

In Bangladesh there is a well-developed market for hired animal power. Nonetheless, draught power plays a crucial role in the allocation of sharecropped land. In rural Bangladesh the accumulation of resources, and more particularly the retention of control over resources in the face of a rapidly rising population, is the key element in the individual's battle to avoid deteriorating living standards. Draught animals are probably the most important resources after land - albeit a long way after - for this purpose. For those who are unable to increase their land holdings because the supply of land is inelastic, the ownership of draught animals provides the next best opportunity. However, since the diet of the animals is largely crop residues, the owner must have access - through sharecropping - to enough land to feed them. In all the areas surveyed the average share tenant cultivates an area which is not substantially less than that cultivated by owner-cultivators or landlord-cultivators. There are virtually no tenants who do not own some land.

Analysis of the results from Noakhali and Comilla shows that owner-tenants cultivate their owned land more intensively than their tenanted land. It would be surprising if this were not the case, since the marginal return to the share tenant is different from the owned land, and from the tenanted land. What, however, is important from the landlord's point of view if whether the return he receives from the tenant is adequate compared with what he might get by cultivating with hired labour.

7.6: Conclusions

All of the above has pointed to a very precarious situation with regard to animal draught in Bangladesh. It suggests a deteriorating availability of animal draught power, at least over the next few years. Of course, the data on which such a view is based are often very shaky. The position requires careful monitoring. The first need is for reliable estimates on a regional basis of age-specific mortalities and also fertility.

Research is required into the factors contributing to low herd productivity and of ways of ameliorating the situation. It can be hypothesised that an important contributory factor is the high mortality of calves. It is important to have sound data on calf mortality. It is also important to examine the causes of calf mortality. Are the mothers stressed through low levels of nutrition, a high incidence of disease, or through working too hard? Do calves have to compete with humans for their mothers' milk? Are calves particularly susceptible to disease?

The data in this survey were not collected to answer questions such as these. Mortality figures are little more than guesses and the calculations of fertility differences between draught and non-draught females are necessarily very crude. Nonetheless, they are adequate to suggest that there is a serious drop in fertility in using cows for draught. The model demonstrates that it is rational for farmers to use females for draught in spite of this drop in productivity. However, the herd cannot be maintained if the overall calving percentage falls below a critical level.

An appropriate response is not to try to dissuade farmers from using females for draught, but to seek ways of minimising the reduction in productivity which this involves. It is necessary to study more closely farmers' practices in using females for draught, especially when they are heavily pregnant or with young calves. The precise components of fertility differences need to be analysed so that policies to minimise them may be devised. Do draught cows have fewer pregnancies? Do they have fewer live calves? Is the mortality of calves with working mothers higher? To what extent is the problem related to cows working during the last few months of their pregnancy?

Arising from the results of such research, policies might be directed towards: special attention to the nutrition of pregnant, working cows; changing the breeding cycle so that the peak period for ploughing does not coincide with the calving season; extension to make farmers aware of the possible cost of female draught; extension to persuade farmers to try to find alternatives to using pregnant females for draught. However, it needs to be stressed that appropriate policies are dependent upon more reliable livestock statistics and upon a careful appraisal of the factors affecting herd productivity.

The nutritional constraint on livestock productivity and on the availability of draught animals is clearly of very great importance in Bangladesh. Given the pressure on human nutrition it is highly unlikely that farmers in Bangladesh will be prepared to set aside land which could be devoted to food especially for fodder crops. On the other hand there could be considerable scope for joint products such as groundnuts or kheshari. It has been shown that the cattle population in Bangladesh is heavily dependent on crop by-products for its sustenance. Cropping policies need to take account of the very high value of these by-products which has been demonstrated in this study.

A major problem for a livestock nutrition policy in Bangladesh is that of preserving organic materials through the monsoon. Hence, foodstuff which can be stored growing has obvious advantages. The planting of leguminous trees and bushes on margins and wastes has been proposed. These could contribute to fertility as well as providing foliage for livestock feed. Since they also provide firewood and building materials, both of which are becoming increasingly scarce in Bangladesh, they are clearly an attractive possibility. Nobody will pretend, however, that they can make more than a minor contribution.

An important possibility is the treatment of straw and other crop residues to improve their nutritive value. Work has already been done in Bangladesh as well as elsewhere and promises to provide cheap and reliable methods for use at farm level (see Gill, 1981, for references).

It needs to be stressed that animal nutrition in Bangladesh is part of the problem of human nutrition. Policies - and research programmes - directed towards improving human food production must also take into account the needs of the draught animals which in their turn contribute to food production.

What are the distributional implications of improving the health and strength of the draught animal population? The question can be looked at over two time periods. First, what is likely to happen in a relatively static situation with fixed ownership of land and draught animals? Secondly, how are the pressures generated in the static situation likely to lead to changes in the distribution of ownership? In particular, is it to be expected that landlords will call in their land to cultivate it themselves, displacing their tenants and causing them ultimately to have to liquidate their draught animal holdings and dispose of what little land they have?

Two situations can be distinguished: improving the value of by-products which are consumed by the draught population; improving the capacity of the animal itself. Consider a landlord letting out land to a share-tenant. Increasing the value of by-products increases the value of the total product of the land, i.e. pushes up the production function. In the first instance, this is shared by the landlord and tenant according to the share proportion. Looking at the other case, improving the capacity of the draught force independently effectively lowers the cost of draught power. In the first instance, this accrues entirely to the owners of draught animals, provided that the rental share is fixed by custom. If there is competition between draught animal owners, the equilibrium between self-cultivation and share-tenancy is disturbed. In the Cheung model this could be restored by an adjustment in the value of the share-proportion. If custom does not allow that, the adjustment mechanism - according to the model in the last chapter - is that the landlord insists on more intensive cultivation. The insistence need not necessarily be very explicit; competition between potential tenants would be the instrument.

From the longer term point of view, is there anything in this to suggest that the owners of land who currently sharecrop it out would start cultivating themselves? It depends really on the efficiency of the adjustment mechanisms just described. Probably the best guarantee of a relatively stable situation is the presence of a pool of potential sharecroppers with, of course, their own draught animals. Policy could be directed towards maintaining this pool, i.e. endeavouring to ensure that farmers in this group do not fall out of it because of loss of their animals.

The view presented here is somewhat different to that of James in the second part of this volume. James maintains that the major difference between mechanical draught and animal draught is one of scale. This is crucial. In other places where mechanisation has led to the displacement of tenants it is probable that one of the major factors is ease of management on, say, a 50 acre holding. This does not arise in Bangladesh. Any innovation benefits certain members of society more than others, but this does not provide adequate grounds for rejecting it. Innovations which lead to an increase in the productivity of scarce resources are likely, on the face of it, to lead to an increase in the economic power of the owners of those resources. However, the exact distribution of benefits depends, in economic terms, on the extent of competition and the various elasticities of supply and demand, and in sociological terms, on the power relations within the society. Increasing the productivity of the national herd should make the long-run supply of draught animals more elastic. It is to be expected that should make it easier for small cultivators to own their own livestock as well as bringing down the price of hired draught power.

Once again the need to improve herd productivity has been stressed. This involves both improving fertility and reducing mortality. In the past in Bangladesh these aims have largely been sought through disease control. In future, much more attention needs to be devoted to nutrition.

Over the years the Bangladesh farmer has clearly worked out a strategy for getting the maximum from his animals with the minimum of input. As the pressure on resources increases there is a danger that he will unwittingly draw the line too fine. The result could be a downward trend in livestock numbers - and animal draught power - that would be very difficult to recover from.

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PART 2

Mechanisation and Institutions in Noakhali

by

Peter James

PREFACE

In 1970, a cyclone and tidal bore swept the coastal area of Bangladesh, killing a quarter of a million people, devastating an area of some 7,500 square miles and destroying an estimated 500,000 cattle.[1] It was feared that, for some time to come, there would be a draught-power constraint on land cultivation. As a response, workshops and tractor hire services were established in Sudharam and Ramgati Thanas in Noakhali District, and in Bhola Town, Patuakhali District, with the assistance of War-on-Want.

Almost ten years later only one of the workshops was in operation and that literally encircled by sundered tractors and dismantled machinery. An evaluation of the project was put in hand, linked with a broader study of farm power in Bangladesh mounted by Reading University at the request of the Bangladesh Ministry of Agriculture.[2]

The Study that follows is focused on a detailed examination of two villages in the Noakhali District. It seeks to show first how the social structure is related to resource control and how this relationship underpins agricultural practice; and second the implications which the introduction of tractors may have for field cultivation and socio-economic change.

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[1] The recent history of such disasters is summarised in Appendix A.

[2] See Reading University Department of Agricultural Economics and Management Development Study No. 19.

CHAPTER 1: INTRODUCTION

1.1: Objectives

The writer's original terms of reference were concerned with the economic, technical and social effects, cost and benefits of the mechanised cultivation scheme, Char Alexander. In the decade since the scheme's inception, the price of crude oil has increased by 600% and is threatening to increase by as much again, while the costs of tractors and spare parts have, somewhat more modestly, increased by 300%. Also, the population of Bangladesh has increased from 68.1 million to an estimated 88.7 million and in the same period the percentage of households effectively landless has risen from approximately 40% to more than half of all rural households. As a result of these and other factors changing the conditions that once pertained when the original decision to introduce tractors was taken, the terms of reference were modified to include an examination of whether continued tractorisation is feasible and required, especially as, given the technical condition of the workshops and tractors, any future tractorisation would require much new investment.

In order to facilitate this modification, the inquiry was linked with the wider paired-village study launched by Reading University; and a detailed sociological survey was undertaken in two villages in Noakhali District, the general aim of which was to establish the social effects resulting from changes in mechanisation.

The study's objectives, in the event, have proved difficult to achieve. The unreliability and inefficiency of the tractor hire services meant that farmers were reluctant to depend on them. Few farmers, if any, sold or postponed the buying of draught animals because of the tractor hire station. Likewise no farmer was found, for instance, who instead of sharecropping his land out, cultivated it himself because of the station. The unreliability of the service has meant that the impact on the social structure has been slight.

Nevertheless, while the sociological survey has not been able to furnish any direct empirical evidence regarding the social consequences of tractorisation, it has provided an opportunity for analysis of a complex social situation. Also, by allowing a detailed study of the function of draught animals, it has been possible to make suggestions about the likely social effects of alternative ways of improving draught power.

Another effect of the unreliability of the tractor hire service was that it reduced the value of any detailed cost benefit analysis undertaken *ex post*.

1.2: The Survey

Two villages were selected for intensive study. One was termed 'mechanised' in the sense that hired tractors were available to cultivate village land, and the other was 'non-mechanised'.

Data were gathered:

(1) as part of the 'core survey', the basis of the comparative studies described by G. J. Gill in Development Study No. 19, in which a sample of farmers were selected, and

(2) in the sociological survey in which every household head in both villages was interviewed. There were 478 households in all. 336 of these were landholders. Distinction needs to be made between five main types:-

- (i) owner-cultivators (116),
- (ii) landlord-cultivators who hire out some land (67),
- (iii) sharecroppers who hire all their land (102),
- (iv) sharecropper-landlords, who own some land (17), and
- (v) landlords who do not cultivate any land (29).

The mechanised village was situated a mile or so from the tractor hire station. The non-mechanised village was eight miles further south, two miles north-west of Ramgati town. The non-mechanised village was the older in terms of settlement, although both communities are relatively young compared to other settlements in Bangladesh. Both are beginning to feel the pressure on land that is common elsewhere in the country. Resources such as fuel and grazing which were once regarded as free and abundant are becoming increasingly scarce: their supply is not yet consciously organised.

The mechanised village had a population of 742 males and 646 females, living in 194 households. The population of the non-mechanised village consisted of 963 males and 808 females living in 284 households. The average size of a household was 7.16 and 6.24 for the mechanised and non-mechanised respectively. The literacy rate was approximately 30% in both villages; though the rate was lower among women. The age structure of the villages was similar with 45% of the population under 14 years of age. Although both villages were less than a mile from an all weather road, such was the condition of the road that the twenty or so miles to Lakshimpur, the nearest town, took five hours and more by motor vehicle. Both villages had primary schools. The mechanised village had a secondary school. Neither village had electricity. Both villages had a market place and a few shops; however, these were more developed in the mechanised village. There were no health facilities in either village. Both villages, being close to the Bay of Bengal, had fishing communities, though this was larger in the non-mechanised village which was next to the sea, nestling in a crook of an embankment that is meant to stop inundation by sea water. The mechanised village was two miles from the sea. In the fishing season, fishermen's wages were lucrative though the work, given the squally nature of the monsoon, is dangerous. Fishing provided an alternative employment to agriculture.

CHAPTER 2: RESOURCES, SOCIAL STRUCTURE AND INSTITUTIONS

Notwithstanding the fact that, in the last twenty years or so, inputs such as chemical fertilisers, pesticides and, more recently, high yielding varieties of rice have become increasingly available, the essential resources for cultivation in the delta villages of Bangladesh have remained what they have been for centuries: namely, land, labour, draught animal power and credit. There is no irrigation. The inter-relationship between the four factors is complex. There may exist, in certain circumstances, a degree or substitutability between then, but for most farmers, access to all four is required for production.

2.1: Land

Land may be regarded as the most important resource. Possession of land alone is sufficient to ensure some income: by sharecropping land out the owner is entitled to 50% of its production. If however the landowner needs or wishes a bigger share of production, then he is dependent on having access to other resources. The need to have access to draught animals and credit can, in certain circumstances, produce a dependency that can threaten the very ownership of land itself.

Land distribution patterns are not homogeneous throughout the regions of Bangladesh. Comparing the survey area to the pattern of land distribution found in rural Bangladesh as a whole (see Table 2.1) the distributions, with two exceptions, are broadly similar. The number of totally landless is higher in the survey area (30%) than in rural Bangladesh (11%). However, the survey area has less (24%) in the 0.01-1.00 acre ownership category compared to overall distribution in rural Bangladesh (47%). In consequence both surveys are in broad agreement that over half the rural households own less than 1 acre of land. The other major difference concerns the larger landowners: the survey area has a higher percentage of households owning more than 10 acres (3.8%) than the national rural survey (1.9%). This divergence is even more apparent if the percentage of total land areas these households own is compared: 11.6% for rural Bangladesh as a whole and 33.2% for the survey area. So while the number of effectively landless households, as well as the general distribution of small and medium landowners is similar the relative proportion of larger landowners is more in the survey area compared to the rest of Bangladesh. With 30% of households landless, a further 40% owning 2 acres or less, and with less than 10% of households owning more than half the land, land distribution is far from even. However, in discussing land areas in Bangladesh 'relative' is the key word. Although the average landholding is small (2.22 acres), small differences in land size are crucial in determining who gets enough to eat and who does not. In addition, the political power associated with uneven land distribution is as important as the uneven distribution of production it engenders. As will be seen later, consideration of the underlying land distribution patterns is (or should be) crucial in determining mechanisation policy.

Besides land-ownership the other major means of access to land is sharecropping. The standard agreement is for the landlord to provide the land and the sharecropper the draught power, labour and seeds; the yield being equally divided between them. A recent trend, limited to

TABLE 2.1: SIZE DISTRIBUTION OF TOTAL OWNED LAND

No. of Acres	RURAL BANGLADESH[1]				SURVEY AREA			
	Nos. of Households (000's)	%	Area (Acres)	%	Nos. of Households	%	Area (Acres)	%
0	1,312	11.1			143	30.2		
.01-1.00	5,621	47.4	1,799	9.3	114	24.1	69.87	6.6
1.01-2.00	1,946	16.4	2,793	14.4	70	14.8	104.08	9.8
2.01-3.00	1,056	8.9	2,552	13.2	51	10.8	125.32	11.8
3.01-4.00	624	5.3	2,153	11.1	29	6.1	101.00	9.5
4.01-5.00	389	3.3	1,742	9.0	13	2.7	60.63	5.7
5.01-6.00	248	2.1	1,334	6.9	12	2.5	64.76	6.1
6.01-7.00	170	1.4	1,102	5.7	8	1.7	46.50	4.4
7.01-8.00	120	1.0	899	4.7	2	0.4	14.73	1.4
8.01-9.00	82	0.7	697	3.6	10	2.1	85.087	8.0
9.01-10.00	50	0.4	476	2.5	4	0.8	38.62	3.6
10.01+	230	1.9	3,803	11.6	18	3.8	352.67	33.2
Missing	-	-	-	-	5		-	-
TOTAL					479	100.0	1,063.27	100.0

Sources: [1]Land Occupancy Survey (USAID, 1978);
[2]Sociological Survey 1979/80.

the high yielding varieties (HYV's), is, in addition to the standard agreement, for the cost of inputs - HYV seeds, fertiliser and, in certain cases, pesticides - to be divided equally between both parties. The yield still being divided equally.

An analysis of the Noakhali selected villages shows, first that, among 336 landowners there is a strongly skewed distribution (Table 2.2A). At one end of the scale 34.4% of the landowners own only 6.5% of the land while, at the other, 5.4%, owning 10 acres or more each, own 33.2% of the land. But, second, 41.7% of all land owned is sharecropped out, by 32.7% of the landowning households. The distribution of households sharecropping out is not limited to big landowners. Simple addition shows that the 50.0% of all households who sharecrop out own three acres or less, although they only account for 12.1% of the land area involved. On the other hand, households owning ten acres or more account for only 15.5% of those households which sharecrop out, and are responsible for 55.2% of the total land area in this category; so sharecropping out is, as might be expected skewed towards the larger landowners.

Moreover the frequency of sharecropping out tends to increase as one goes up the land-owning scale. In fact, one interesting fact to emerge from an analysis of sharecropping out has great significance in examining the consequences of mechanisation. One can distinguish between:

TABLE 2.2.A: DISTRIBUTION OF LAND SHARECROPPED OUT AND IN

Size Group (Acres Owned)	TOTAL		SHARECROPPED OUT				SHARECROPPED IN			
	% of Sample Households	% of Acres	% of Sample Households	% of Acres, Sample Households	% of Households in Size Group	% of Land Sharecropped Out	% of Sample Households	% of Acres, Sample Households	% of Households in Size Group	Average Acres Sharecropped In
0.01-1.00	34.4	6.5	13.6	1.2	13.2	7.0	36.1	35.5	37.8	2.15
1.01-2.00	21.2	9.8	15.5	3.1	24.3	13.3	22.7	20.0	38.6	1.93
2.01-3.00	15.4	11.8	20.9	7.8	45.0	27.6	15.1	18.8	35.3	2.72
3.01-4.00	8.8	9.5	10.0	4.9	37.9	19.7	8.4	7.7	34.5	2.00
4.01-5.00	3.9	5.7	3.6	2.4	30.8	17.8	5.8	5.4	53.8	2.01
5.01-6.00	3.6	6.1	6.4	6.0	58.3	41.1	0.8	0.9	8.3	2.28
6.01-7.00	2.4	4.4	5.5	6.3	75.0	61.7	2.5		37.5	1.40
7.01-8.00	0.6	1.4	1.8	1.5	100.0	45.8				
8.01-9.00	3.0	8.0	5.5	9.4	60.0	49.2	2.5	3.8	30.0	3.27
9.01-10.00	1.2	3.6	1.8	2.4	50.0	27.6	3.4	3.6	100.0	2.38
10.00+	5.4	35.2	15.5	55.2	94.4	70.7	2.5	2.6	16.6	2.21
TOTAL	100.0 (336)	100.0 (1063.26)	100.0 (110)	100.0 (443.06)	32.7	41.7	100.0 (119)	100.0 (260.18)	35.4	2.37

TABLE 2.2.B: CULTIVATED LAND AND EFFECTIVE LANDHOLDING

Size Group (Acres Owned)	CULTIVATED LAND[1]				EFFECTIVE LANDHOLDING[2]	
	% of Sample Households	% of Acres, Sample Households	% of Households in Size Group	Average Acres Cultivated	% of Acres in Sample Households	Average Acres
0.01-1.00	36.1	18.7	95.6	1.52	12.1	1.03
1.01-2.00	21.5	16.2	92.9	2.19	12.7	1.76
2.01-3.00	14.2	15.9	84.3	3.25	13.6	2.60
3.01-4.00	8.9	11.5	93.1	3.74	10.4	3.49
4.01-5.00	3.6	7.3	84.6	5.81	6.4	4.45
5.01-6.00	3.3	4.6	83.3	4.04	5.4	4.38
6.01-7.00	2.3	2.5	87.5	3.09	3.5	4.87
7.01-8.00	0.7	0.9	100.0	3.99	1.2	5.68
8.01-9.00	2.6	6.0	80.0	6.63	7.1	6.91
9.01-10.00	1.3	4.2	100.0	3.75	3.9	9.51
10.00+	5.3	12.3	88.8	6.75	23.7	12.89
TOTAL	100.0 (302)	100.0 (880.90)	90.6	2.94	100.0 (972.06)	2.88

[1]Cultivated Land = Owned Land Cultivated + Sharecropped in land

[2]Effective Land = Owned Land Cultivated + Land Sharecropped Out/2 + Land Sharecropped in/2.

Source: Sociological Survey.

a) landlords: these landowners sharecrop out <u>all</u> their land; they represent 26.4% of all households sharecropping out and own 24.2% of the land in this category; whereas
b) landlord cultivators sharecrop out <u>part</u> of their land and cultivate the rest; they represent 73.6% of households sharecropping out and own 75.8% of the land in this category.

For whatever reasons landholders sharecrop out land - competing non-farm business interest, family obligations, or lack of access to other means of production - approximately half of these landholders cultivate more than one half of their landholdings. They are cultivators and as such could quickly and easily cease sharecropping and cultivate all their own land themselves. The degree to which mechanisation would affect this propensity to cease sharecropping is a crucial variable in analysing the effects of mechanisation. This discussion must await an examination of the distribution of other resources. Suffice to say here that there exists a significant category of cultivating households who sharecrop out less than half their land.

In the villages surveyed 35.4% sharecrop in land.[1] It can be seen from Table 2.2.A that the acreage sharecropped in is taken up chiefly by those households in the smaller land-owning groups; moreover the areas sharecropped in are, among the small landowners, large relative to the area owned. Nevertheless, the picture, often portrayed, of the typical sharecropper as being a small landowner is a little misleading. As Table 2.2.A shows both medium and large landowners also sharecrop in land. As can be seen by a re-arrangement of the data in Table 2.3 it is possible here to categorise 73 sharecroppers into
a) those who sharecrop in less than one acre (averaging 1.85 land area owned and adding 0.56 acres sharecropped), and
b) those who sharecrop in more than one acre (averaging 2.89 acres owned and adding 3.28 acres sharecropped).

This Table suggests that there are sharecroppers who sharecrop in to try to achieve subsistence level, while there are other sharecroppers who have already sufficient land for subsistence before they even start to sharecrop in.

Tables 2.2.A and B summarise the general picture of land distribution: that land is unevenly distributed by ownership but that sharecropping apparently goes some way to improving access to land for those households which have insufficient land on which to subsist. Thus the Tables show that the 57.6% of households(who own less than two acres own a mere 16.3% of the cultivated area) actually cultivate 34.9%. Yet no less than 17.5% of landowners, with more than four acres, sharecrop in land. Indeed it is noteworthy that, in spite of substantial sharecropping out, the large owners mostly are themselves cultivators (varying from 80-100% in the largest size groups).

To assist in analysing the relationship of land to other resources, another concept is required: effective landholding. This refers to the land from which households receive all or part of the product.

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[1] An additional 4% of households both sharecrop out <u>and</u> sharecrop in land.

TABLE 2.3: DISTRIBUTION OF SHARECROPPERS BY AREA OWNED AND AREA SHARECROPPED IN

	Owns two acres or less	Owns more than two acres	Total
Sharecrops one acre or less			
No. of Households	36	14	50
Average Area Owned (acres)	0.98	4.09	1.85
Average Sharecropped in	0.54	0.57	0.56
Sharecrops more than one acre			
No. of Households	37	34	71
Average Area Owned (acres)	0.91	5.04	2.89
Average Area Sharecropped in	3.47	3.06	3.28
TOTAL AREA SHARECROPPED IN			
No. of Households	73	48	121
Average Area Owned (acres)	0.94	4.76	2.46
Average Area Sharecropped in	2.03	2.35	2.16

Source: Sociological Survey

TABLE 2.4: DISTRIBUTION OF EFFECTIVE LANDHOLDING

No. of Acres	Land Holding				Effective Landholding			
	Households		Area		Households		Area	
	No.	%	Acres	%	No.	%	Acres	%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
.01-1.00 a)	114	34.4	6987	6.5	92	27.6	5685	5.9
1.01-2.00	70	21.2	10408	9.8	91	27.3	13889	14.3
2.01-3.00 b)	51	15.4	12532	11.8	41	12.3	10154	10.4
3.01-4.00	29	8.8	10100	9.5	33	9.9	12093	12.4
4.01-5.00	13	3.9	6063	5.7	25	7.5	11112	11.4
5.01-6.00	12	3.6	6476	6.1	14	4.2	7470	7.7
6.01-7.00	8	2.1	4650	4.4	4	1.2	3391	3.5
7.01-8.00 c)	2	0.6	1473	1.4	6	1.8	2969	3.1
8.01-9.00	10	3.0	8508	8.0	6	1.8	5095	5.2
9.01-10.00	4	1.2	3862	3.6	4	1.2	2779	2.9
10.00 +	18	5.4	35267	33.2	17	5.1	22609	23.2
Missing	5				5			
TOTAL	336		106326		338		97246	

Effective Landholding = Owned Land Cultivated + Land Sharecropped out /2 + Land Sharecropped in /2.

Source: Sociological Survey.

It is calculated by adding to the area of cultivated land owned a half of any land sharecropped in or out. (The product from sharecropping agreements is normally split 50:50 between owner and tenant). Table 2.2.B shows average effective landholding sizes in land-owned size groups. 34.4% of the smallest category are now seen to control 12.1% of the effective landholding, while 5.4% in the largest category are seen to control 23.7% of the effective landholding.

Table 2.4 redistributes households according to effective landholding. They may be divided,[1] albeit crudely into

a) below-subsistence holdings (0.01-2 acres),
b) marginal holdings (2.01-4 acres),
c) and surplus-producing holdings (more than 4 acres).

This categorisation is based on the assumption that in this non-irrigable survey area two rice crops can be grown: Aus and Aman. The average yield is around 20 maunds for both crops. Allowing one seer (2.2 lbs) of rice per person per day and an average 6 persons per household, the total yield from two to four acres is regarded as sufficient to cover the cost of production and enable the family to subsist. As was reported earlier, households owning less than 2 acres own 16% of the land, but through sharecropping they cultivate 35% of the area. Yet, as Table 2.4 shows the percentage of households owning less than 2 acres is the same as the percentage of households whose effective landholding is less than 2 acres - at just over 55%. A comparison of the relative frequency of households according to land ownership and effective landholdings (Table 2.4, cols. (4) and (8)) shows a degree of congruency. Sharecropping, it appears, although relocating some individual households leaves the basic inequality of access to land much the same.

Why does sharecropping do so little to improve access to land? Figure 2.1 attempts to illustrate the mobility from land ownership categories to sub-subsistence, marginal and surplus effective landholding categories. Thirty two households (9.6% of all households) moved 'upwards' from sub-subsistence and marginal land ownership categories to marginal and surplus effective landholding categories through sharecropping in land. Coincidentally, 32 households (9.6 % of all households) moved 'downwards' from surplus and marginal land-owning categories to marginal and sub-subsistence effective landholding categories by sharecropping out land. An analysis of this upward mobility must await a discussion of draught animal ownership.

2.2: Draught Animals

The cattle density of the survey area is two-thirds that found elsewhere in Bangladesh. As Table 2.5 shows, 60.4% of all animals are bullocks used for draught; while another 24% are cows used for milk, breeding and draught purposes. Only 8.7% of all cattle are used solely for milk production and the rest, 6.9% are calves or those whose purpose is unknown. Figure 2.2 is the age-sex pyramid for all cattle. Bullocks in the higher age bracket are not being replaced. The pyramid is partly distorted as a result of the 1970 cyclone.[2]

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[1] See Bertocci (1972) pp. 36-37; Wood (1976) pp. 46-47.

[2] For causes and implications of non-replacement of draught animals see Mettrick (1981) in this volume.

FIGURE 2.1.

		Land Owned No. of Households	Effective Landholding No. of Households
SUBSISTENCE	1. OWNER/CULTIVATOR	85	85
	2. SHARECROPPED	68	46
	3. CULTIVATOR/LANDLORD	17	29
	4. LANDLORD : SHARECROP ALL LAND OUT	10	20
	5. OTHER	3	5
	6. TOTAL	183	182
MARGINAL	1. OWNER CULTIVATOR	21	21
	2. SHARECROPPER	25	33
	3. CULTIVATOR/LANDLORD	21	15
	4. LANDLORD : SHARECROP ALL LAND OUT	10	4
	5. OTHER	3	2
	6. TOTAL	78	76
SURPLUS	1. OWNER CULTIVATOR	10	10
	2. SHARECROPPER	14	28
	3. CULTIVATOR/LANDLORD	29	23
	4. LANDLORD : SHARECROP ALL LAND OUT	9	5
	5. OTHER	5	8
	6. TOTAL	67	74
	GRAND TOTAL	328	332

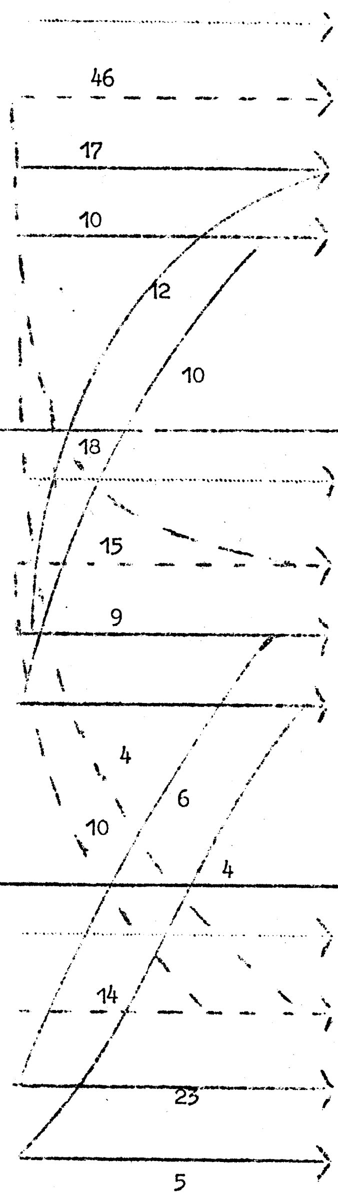


FIGURE 2.2: AGE-SEX PYRAMID OF CATTLE

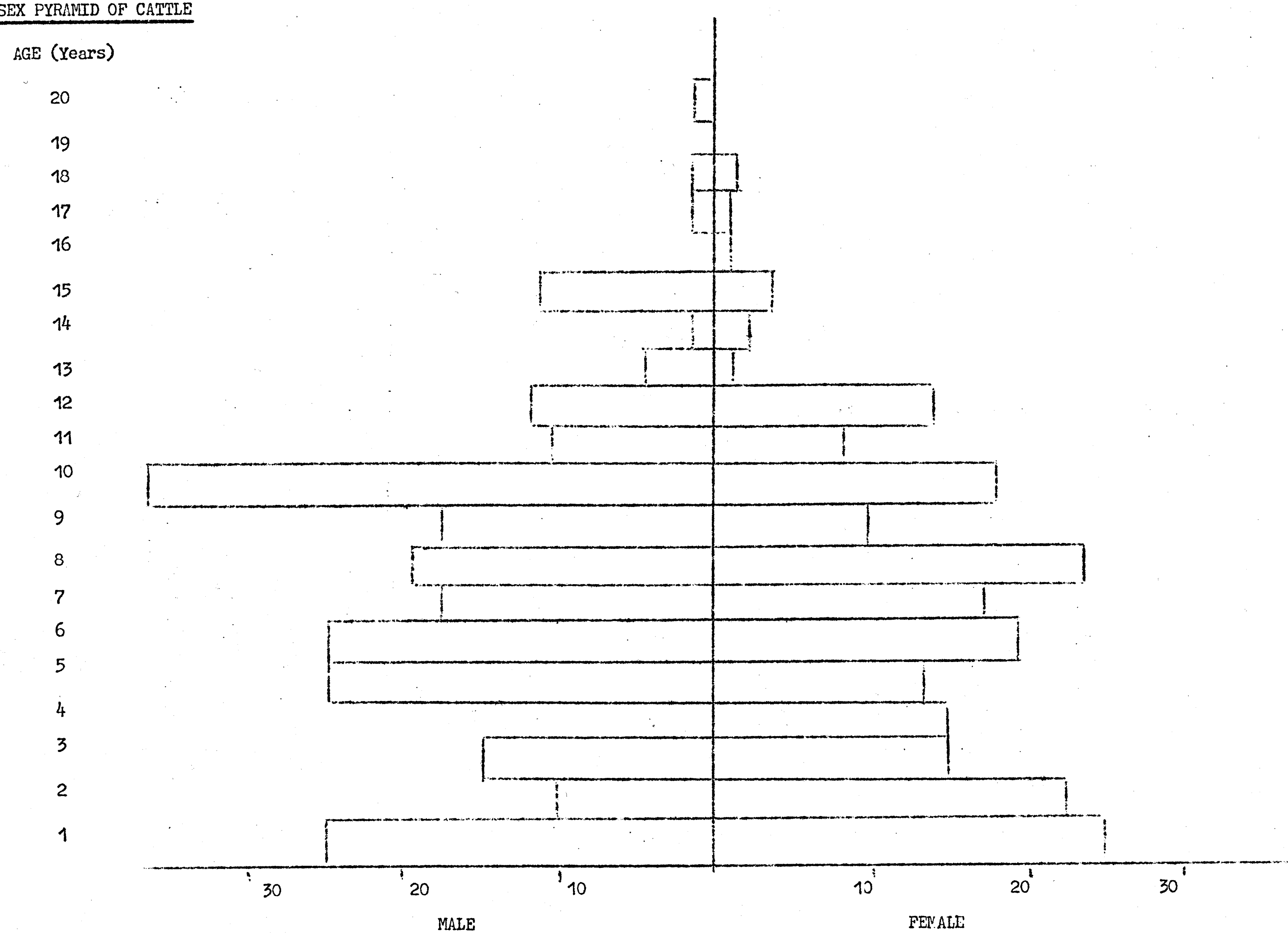


TABLE 2.5: DISTRIBUTION OF CATTLE BY PURPOSE

Purpose	Mechanised Village No.	Mechanised Village %	Non-Mechanised Village No.	Non-Mechanised Village %	Total Survey No.	Total Survey %
Draught Cultivation	101	66.4	191	57.7	292	60.4
Milk & Draught Cultivation	37	24.3	79	23.9	116	24.0
Milk Production	10	6.6	32	9.7	42	8.7
Calves	3	2.0	4	1.2	7	1.5
Others	1	0.7	25	7.5	26	5.4
TOTAL	152	100.0	331	100.0	497	100.0

Source: Sociological Survey

TABLE 2.6: DISTRIBUTION OF HOUSEHOLDS BY NUMBER OF CATTLE OWNED

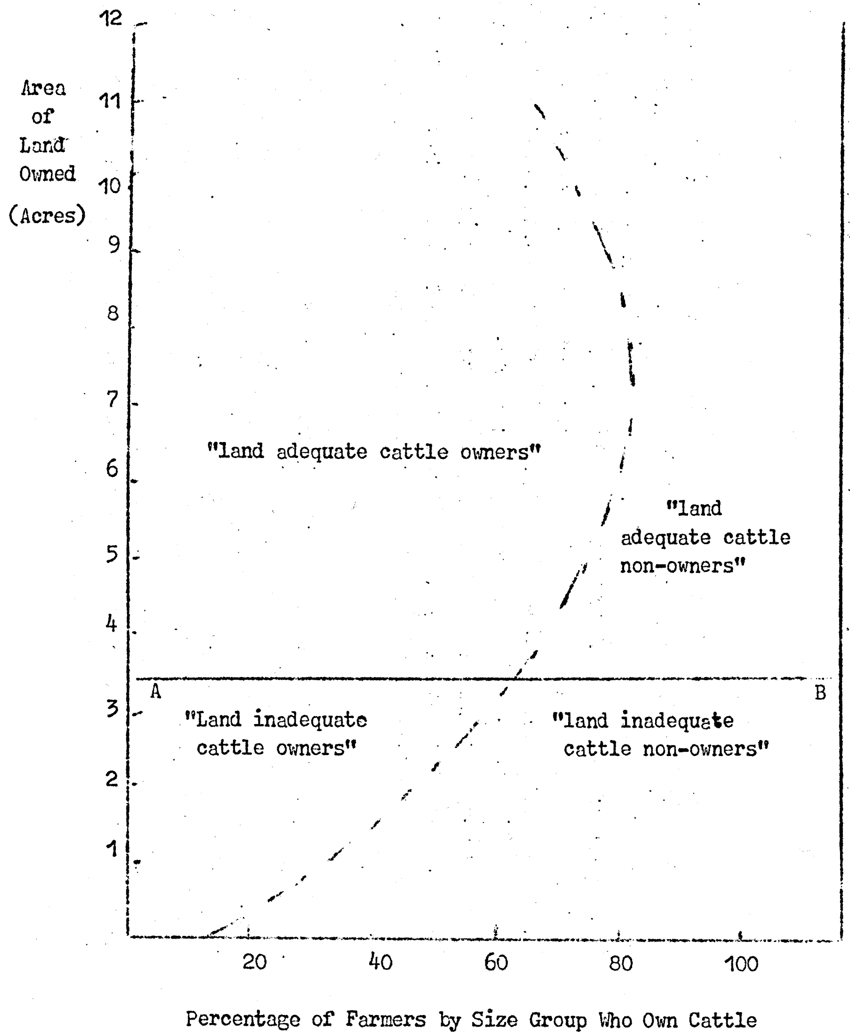
No. of Animals	No. of Households			No. of Animals	
	No.	%	Adj. Freq.	No.	Adj. Freq.
0	150	44.4			
1	39	11.5	20.7	39	7.9
2	78	23.0	41.5	156	31.4
3	26	7.7	13.8	78	15.7
4	24	7.1	12.8	96	19.3
5	11	3.3	5.9	55	11.1
6	6	1.8	3.2	36	7.2
8	2	0.6	1.1	16	3.2
10	1	0.3	0.5	10	2.0
11	1	0.3	0.5	11	2.2

Source: Sociological Survey

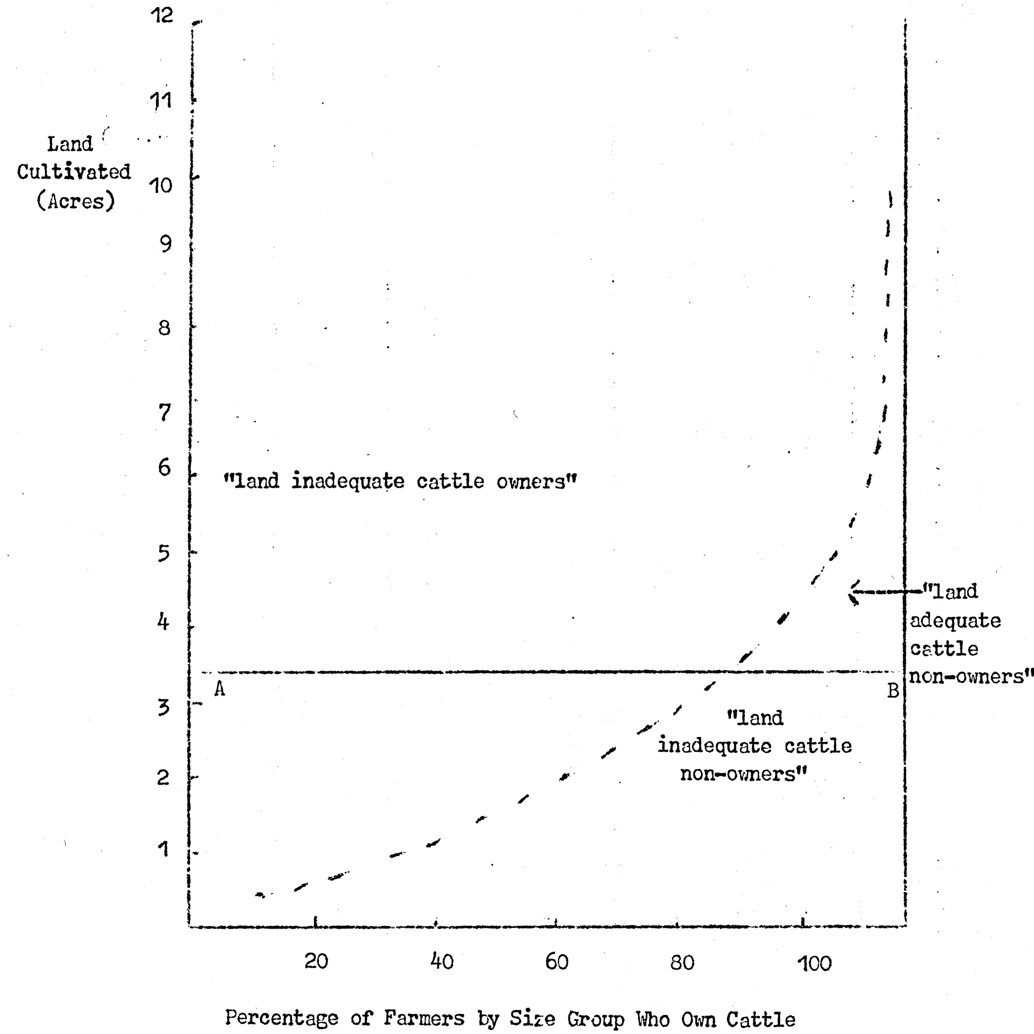
As Table 2.6 shows 44.4% of all households (ignoring landless households) do not own any cattle at all. 60% of those households hire-in draught animals; 20.1% are self-sufficient for draught power; 17.2% hire-out their animals, and 2.6% both hire-in and hire-out draught power. (These figures do not include animals exchanged or hired-out free of charge). The high percentage of households hiring-in draught animals includes those who always hire-in - they do not own draught animals - as well as those who own draught animals and who only hire-in animals occasionally. The figure does, however, give an indication of those without sufficient draught power to cultivate the land themselves.

Graph 2.1 sketches the relation between the percentage of farmers by farm size group who own cattle and the land area owned. Not surprisingly the percentage of households owning cattle declines as the land area owned gets smaller. The distribution diminishes more rapidly under two acres of land owned. Nevertheless, there are a number of small landowners owning draught animals. The minimum amount of land required to feed two draught animals depends on many factors and an estimation of such an amount is to a large extent

GRAPH 2.1: SKETCH OF RELATIONSHIP BETWEEN LAND AND CATTLE OWNERSHIP



GRAPH 2.2: SKETCH OF RELATIONSHIP BETWEEN LAND CULTIVATED AND ANIMALS OWNED



arbitrary. An average of farmers' estimations suggest a pair of bullocks can cultivate at least five acres during either of the two major rice seasons. Another average of farmers' estimations suggests that three and a half acres will provide sufficient straw and crop residues to feed two animals. No fodder crops are grown, so it is doubtful whether three and a half acres could provide sufficient nutrition without some cattle feed, such as oilcake, being bought. At present grazing on bunds and in the char land appears to be the main source of nutritious feedstuff for cattle.

Nevertheless, let line AB in Graph 2.1 represent an estimation - three and a half acres - of the amount of land required to feed two bullocks. This gives rise to four categories of households:

(1) "land adequate cattle owners" - those who own sufficient land to feed a pair of draught animals and who own draught animals (16% of households);

(2) "land adequate cattle non-owners" - those who own sufficient land to feed a pair of draught animals but who do not own draught animals (9% of households);

(3) "land inadequate cattle owners" - those who own insufficient land to feed a pair of draught animals, yet they own draught animals (37% of households); and

(4) "land inadequate cattle non-owners" - those who own insufficient land to feed a pair of draught animals and do not own draught animals (38% of households).

"Land adequate cattle non-owners" are landowners who sharecrop out much of their land and/or who have major business interests besides farming. Sixty-four per cent of "land inadequate cattle owners" sharecrop in land, using the extra land to utilise their spare draught capacity and to provide needed straw and other crop residues. Graph 2.2 shows a similar picture but with cultivated area on the vertical scale. The number of cattle owners by size of cultivated area, cultivating less than three and a half acres, is more than the number of cattle owners by area of land owned, owning less than three and a half acres. However, there are still farmers without sufficient land - whether owned or sharecropped in - to feed their animals. More than half of the "land inadequate cattle owners" category who sharecrop in land still have insufficient access to enough land to feed their animals. Only half of these cultivators hire-out their animals. One surprising fact is that out of the 37 cattle owners who do not sharecrop in land in the "land inadequate cattle owner" category, only four hire-out cattle.

Before discussing the behaviour of these groups further it is necessary to analyse briefly the relationship between draught animals and landholdings. Examining first the category of owner-cultivators (Table 2.7.A): 75% of households in this category hire-in, 13.8% hire-in and -out; only 11.2% hire-out cattle. This would suggest that owner-cultivators, if they have excess draught animal capacity, prefer to sharecrop in land. The majority of the nineteen households who own cattle, but still hire-in, own only one draught animal. Of the thirteen cultivators who hire-out, seven have land-holdings less than three acres.

Households who sharecrop out all their land (8.7%) own no draught animals and by definition do not hire-in draught power. Of those who cultivate some land and sharecrop out the rest, (Table 2.7.B), 77.6% of hired-in cattle. Like owner-cultivators, the majority of landlord

TABLE 2.7.A: DISTRIBUTION OF OWNER CULTIVATOR BY LAND AREA AND ACCESS TO CATTLE

EFFECTIVE LANDHOLDING (ACRES)	NON-OWNERS	CATTLE OWNERS			TOTAL
	Hire-In	Hire-In	Hire-In Hire-Out	Hire-Out	
1. 0.01-2.00	58 (68.2)	14 (16.5)	9 (10.6)	4 (4.7)	85
2. 2.01-4.00	10 (47.6)	1 (4.8)	5 (23.8)	5 (23.8)	21
3. 4.01+		4 (40.0)	2 (20.0)	4 (40.0)	10
TOTAL	68 (58.6)	19 (16.4)	16 (13.8)	13 (11.2)	116

TABLE 2.7.B: DISTRIBUTION OF LANDLORD CULTIVZTORS BY LAND AREA AND ACCESS TO CATTLE

1. 0.01-2.00 owns ≤ 2.00	13 (76.5)	4 (23.5)			17
2. 0.01-2.00 owns > 2.00	6 (50.0)	3 (25.0)	3 (25.0)		12
3. 2.01-4.00 cultivates ≤ 2.00	4 (57.1)	2 (28.6)	1 (14.3)		7
4. 2.01-4.00 cultivates > 2.00	4 (50.0)	2 (25.0)	2 (25.0)		8
5. 4.01+ cultivates ≤ 2.00	6 (60.0)	1 (10.0)	3 (30.0)		10
6. 4.01+ cultivates > 2.00	4 (30.8)	3 (23.1)	4 (30.8)	2 (15.3)	13
TOTAL	37 (55.2)	15 (22.4)	13 (19.4)	2 (3.0)	67

TABLE 2.8: DISTRIBUTION OF SHARECROPPERS BY LAND AREA AND ACCESS TO CATTLE

EFFECTIVE LANDHOLDING (ACRES)	NON-OWNERS	CATTLE OWNERS				TOTAL
	Hire-In	Hire-In	No Hire	Hire-In Hire-Out	Hire-Out	
1. 0.01-2.00 sharecrops < 1.00	10 (32.3)	7 (22.6)	4 (12.9)	4 (12.9)	6 (19.4)	31
2. 0.01-2.00 sharecrops 1.01+	2 (13.3)	3 (20.0)	2 (13.3)	1 (6.7)	7 (46.7)	15
3. 2.01-4.00 sharecrops < 1.00	3 (27.3)	4 (36.4)	2 (18.2)		2 (18.2)	11
4. 2.01-4.00 sharecrops 1.01+	2 (9.1)	3 (13.6)	8 (36.4)	1 (4.5)	8 (36.4)	22
5. 4.01+ sharecrops < 1.00		1 (20.0)	3 (60.0)		1 (20.0)	5
6. 4.01+ sharecrops 1.01+	1 (4.3)	3 (13.0)	10 (43.5)	2 (8.7)	7 (30.4)	23
TOTAL	18 (16.8)	21 (19.6)	29 (27.1)	8 (7.5)	31 (29.0)	107

Source: Sociological Survey.

cultivators who own cattle and also hire-in cattle, own one draught animal. The two cultivators who hire-out their animals own 14 and 8 acres respectively and cultivate 7 and 5 acres respectively. The pattern of cattle ownership and hiring is much the same for this category as it is for owner cultivators.

The pattern, however for those who sharecrop in land, is very different compared to owner cultivators and cultivator landlords (Table 2.8). Over 80% of cultivators who sharecrop in own cattle (compared to 40% for the other two categories). Of the 18 households who do not own cattle 13 households sharecrop in less than one acre, and another two households own less than 2 acres of land. Of the 21 households who own cattle but also hire-in cattle, 11 owned only 1 draught animal. The most significant observation however concerns the 31 households who hire-out their animals. Of these 31 households 24 of them own less than 3 acres, though as a result of sharecropping only 12 cultivate less than 3 acres.

Returning to the four categories differentiated on Graph 2.1, Table 2.9 compares respective characteristics of "land adequate cattle owners" and "land inadequate cattle owners". Consider the latter - those that own insufficient land to feed two draught animals. Excluding those cultivators who own only one draught animal, the most surprising observation is that a significant number of households in this category neither sharecrop in land nor hire-out their animals - indeed 12 of these households even hire-in draught capacity. Part of the explanation lies in the way the data were collected: "hiring-in" covers cultivators who hire-in substantial amounts of draught power and people who hire-in only occasionally. In addition the survey was unable to measure the quality of animals, yet the size of land area two draught animals could work varied considerably, anywhere between 1.5 acres to three acres a day. If, as it is not unreasonable to assume, the smaller farmers have the poorer quality cattle then the draught animals belonging to these households might not be capable of cultivating more land area than their owners own. But none of these possible explanations deals with the problem of how the animals are fed. Animals belonging to this sub-category must be reliant on free grazing. Farmers owning these animals may well be the rump of what was once a considerably larger group of cultivators who used to own animals and sustained them on the free grazing in the <u>char</u> lands. Many of the older farmers can remember vast areas of grazing, now registered and settled through government schemes, that supported cattle throughout the year. Animals were only brought to the farms during the period of land preparation. Such grazing land is rapidly disappearing; this has two implications. First, it means the disappearance of a source of nutritious foodstuff and hence a need to use more crop residues and buy more animal fodder as well as an increase in pressure for growing animal fodder crops. Secondly, it also means that it is becoming increasingly more difficult for farmers who own less than three and a half acres or so to own cattle, without sharecropping in land or hiring-out their cattle. While there have always been smaller landowners hiring-in cattle, their incidence has increased as free grazing has disappeared. The existence of such a trend has important implications for mechanisation policy. The increasing number of smaller farmers unable to own cattle as land formerly grazed is cultivated will increase the demand for cattle hiring services, and this at a time when the supply of services could be concentrating into fewer hands.

TABLE 2.9: DISTRIBUTION OF CATEGORIES OF CATTLE OWNERS BY ACCESS TO DRAUGHT POWER

	LAND ADEQUATE CATTLE OWNERS						LAND INADEQUATE CATTLE OWNERS						TOTAL	
	Cultivators		Sharecroppers		Total		Cultivators		Sharecroppers		Total			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1. Own 1 Draught Animal and Hire-in	5	16.7	1	4.2	6	11.1	11	22.9	9	11.8	20	16.1	26	14.6
2. Own > 1 Draught Animal and Hire-in	6	20.0	3	12.5	9	16.7	12	25.0	10	13.2	22	17.7	31	17.4
3. Neither Hire-in nor Hire-out	13	43.3	10	41.7	23	42.6	16	33.3	22	29.0	38	30.7	61	34.3
4. Hire Cattle Out	6	20.0	9	37.5	15	27.8	9	18.8	28	36.8	37	29.8	52	29.2
5. Hire Cattle In and Out			1	4.2	1	1.9			7	9.2	7	5.7	8	4.5
TOTAL	30		24		54		48		76		124		178	

Source: Sociological Survey

Considering other "land inadequate cattle owners" 76, or 61.3%, of households sharecrop in land. The importance of access to this extra land is crucial to a household's ability to ensure ownership of the draught animals. Interestingly, although 37 (29.8%) of households in the "land inadequate cattle owners" category hire-out animals, only nine of those who do so do not sharecrop in land. The biggest subcategory is farmers who hire-out cattle and sharecrop in land. Twenty eight "land inadequate cattle owners" own more than one draught animal, yet do not sharecrop in land, nor hire-out their animals. Some households in this position may be lending their animals out to family members, or they may be getting straw and crop residues from family members who have no use for these products. However they manage it, their ownership of draught power is marginal.

As can be seen from Table 2.9, cultivators (taking owner-cultivators and sharecroppers together) who hire-out cattle are to be found in both categories of cattle owners, with 29.7% and 35.5% of "land adequate cattle owners" and "land inadequate cattle owners" hiring-out draught animals respectively. If some small landholders can own cattle why cannot other, or even all, small landholders own cattle? Two brief comments. First, presumably cultivators in the "land inadequate cattle owner" category have better access to capital and, particularly credit, than cultivators in "land inadequate cattle non-owner" category. The second comment concerns why "land inadequate cattle owners" prefer to hold resources in cattle rather than land. What is the trade-off between cattle and land? Why do not "land inadequate cattle owners" sell their cattle and buy more land? On the other hand, why do not "land inadequate cattle non-owners" sell part of their landholding and buy cattle? At least part of the answer is that land is viewed as a much more secure asset than cattle, and as such, cattle may be sold to buy land, but selling land to buy cattle would be viewed as unnecessarily risky, given the danger of cyclones and the fact that land will always give half its production.[1] In the case of selling cattle to buy land, although there are occasionally outright land sales, land is also transferred through mortgage defaulting. Rarely will farmers ever have the practical choice of selling cattle to buy land. Whatever the reasons might be, as to why among households who own insufficient land to feed two draught animals, some own cattle and others do not, the major point to stress is that cattle ownership is a zero sum game. Even though the present cattle density may increase, the number of draught animals a given area of land can feed is fixed, if the average landholding and/or farm is below the amount of land needed to feed a pair of draught animals, then some landowners or farmers will not be able to own a pair of draught animals. If there were abundant free grazing, this would not be so. But, if, as is apparently happening in the survey area, the amount of free grazing land contracts, then the number of cattle non-owners will increase.

Among the implications of the above analysis two are especially important for mechanisation analysis:

(1) the dependence of "land inadequate cattle non-owners" on cattle owners; and

(2) the precarious position of "land inadequate cattle owners", especially in terms of their reliance on sharecropped land.

2.3: <u>Labour</u>

The Survey was concerned with the labour deployment for field operations. There is a rigid sexual division of labour in agriculture: men work in the fields and women process crops, though if garden plots are sufficiently secluded, women will also tend them. Occasionally tasks, such as jute retting, are performed by women away from the curtain of purdah; such women have very low social status. While not for a moment denying the critical contribution female labour makes to agricultural production, because the survey was concerned with field operations, the analysis is not able to deal with the impact of mechanised cultivation on female employment opportunities.

Division of labour on the basis of age is far less clear cut than on the basis of sex. There is a tendency, not unexpectedly, where adolescents and even children are just as productive as adults, to employ the younger, cheaper labour. So tasks such as grazing, collecting and cutting fodder and herding are undertaken more often by adolescents and children, and in some cases, older men and even women. For the main agricultural field work, however, there is little preference, if any.

Two major sources of labour are: family and casual labour. The typical farm labour force for field operations consists of a father and one or two adolescent sons. Such a labour force is likely to be sufficient for all field operations with the important exceptions of transplanting and harvesting, and, to a lesser extent, weeding. If animals have to be hired, then invariably the hirer has little choice but to hire-in the ploughman also. In addition almost all cultivators hire labour in, and most of this casual labour

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[1] There were in fact two households where land had been sold to buy cattle.

TABLE 2.10: DISTRIBUTION OF OBSERVATIONS OF TASKS

Task	No. of Observations	%	% (Agric.Tasks Only)
Herding, Feeding Animals	61	10.9	19.2
Ploughing	55	9.9	17.3
Other Cultivation Tasks	168	30.1	53.0
Other Agricultural Tasks	33	5.9	10.4
Non-Agricultural Work	109	19.5	
No Work	86	15.4	
Others	46	8.2	
TOTAL	558	100.0	100.0

Source: Weekly Survey of Core Sample Households

TABLE 2.11: OCCUPATIONS OF LANDLESS HOUSEHOLD HEADS

	MECHANISED VILLAGE		NON-MECHANISED VILLAGE		TOTAL	
	No.	%	No.	%	No.	%
Agricultural Labourer	38	62.3	55	68.8	93	66.0
Fishing	6	9.8	3	3.8	9	6.4
Trading & Rickshaw Pulling	11	18.0	7	8.8	18	12.8
No Visible Means of Support *	6	9.8	15	18.8	21	14.8
TOTAL	61		80		141	

Source: Sociological Survey. *Beggars, sick, unemployed, infirm.

TABLE 2.12: DISTRIBUTION OF AGRICULTURAL LABOURERS BY LAND ACCESS CATEGORIES

	Households with at least One Member an Agricultural Labourer No.	Households with No Member Employed as an Agricultural Labourer No.	Total of all Households No.	%
Landless	93	48	141	29.8
Effective Holding 0.01-2.00 acres				
Owner/Cultivator	32	53	85	17.9
Sharecropper	20	26	46	9.7
Cultivator/Landlord	6	22	28	5.9
Landlord	2	22	21	4.4
Sharecropper in & out	2	0	2	0.4
Effective Holding 2.01-4.00 acres				
Owner/Cultivator	3	19	22	4.6
Sharecropper	8	25	33	7.0
Cultivator/Landlord	0	16	16	3.4
Landlord	0	3	3	0.6
Sharecropper in & out	2	1	3	0.6
Effective Holding 4.01+ acres				
Owner/Cultivator	0	10	10	2.1
Sharecropper	2	26	28	5.9
Cultivator/Landlord	0	20	20	4.2
Landlord	0	8	8	1.7
Sharecropper in & out	0	8	8	1.7
TOTAL	170	304	474	100.0

Source: Sociological Survey.

is limited to transplanting, harvesting and weeding. The introduction of any form of mechanisation into these particular tasks will have the very serious impact of reducing casual labour opportunities. In terms of the introduction of mechanised cultivation, the effects on employment opportunities depend on whether mechanisation is limited to land preparation or whether it will also be used for transplanting, harvesting and other tasks.

Draught animal power generates two major types of employment:
(a) herding and collecting animal fodder, and
(b) working as a ploughman.
The former is undertaken to some extent by adolescent males and the latter by the owner of the animal or by permanent labourers who look after the animals. It is difficult to get an accurate measure of days spent looking after animals, since it is often combined with other tasks. But a large amount of time is spent herding or collecting fodder or cutting grass. Table 2.10 gives the crude distribution of observations of herding vis-a-vis other tasks: herding and collecting fodder accounted for some 10% of all observations reported in the weekly survey. Herding and collecting animal fodder account for almost 20% of all reported agricultural activities. Allowing for the fact that the observations are crude, it is evident that herding and collecting fodder are very time consuming tasks.

The importance of agricultural employment to the landless is illustrated in Table 2.11: 66% of all landless household heads are dependent on agricultural labouring. However, as Table 2.12 shows, this accounts for only part of the agricultural labour force. Others come from those whose effective landholdings are less than 2 acres and from sharecropping households.

Given the relationship to land and the structure of agricultural labour outlined in Table 2.12, it is possible to categorise households into their major socio-economic categories:-
- (a) labourers (30% of households),
- (b) owner-cultivators (25% of households),
- (c) sharecroppers (23% of households),
- (d) cultivator/landlords (14% of households), and
- (e) landlords (7% of households).

2.4: Credit

Although no detailed analysis of credit is made in this study its importance must be borne in mind during the ensuing analysis.

Two-thirds of the farmers usually borrow money either to buy food or cover expenses incurred in growing crops, or both. In terms of meeting running costs the money is used (1) to pay for animals hired, (2) pay casual labourers, and (3) to buy chemical fertiliser. The average loan is 650 taka. More than half the loans are interest free from cognate[1] relations and neighbours. Approximately, another quarter of all loans are from banks and agricultural co-operatives:

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[1] Cognate relations are those related by "blood", as opposed to affine relations who are related through marriage.

interest rates are 10-11% per annum. The other quarter of loans come from moneylenders and relatives lending at high, even exorbitant, rates of interest: 5-10% per month being the norm. These loans are usually for a short duration, three or four months. Money borrowed at interest rates of 100% per annum, which are not uncommon, of course effectively doubles the cost of any input that the money may buy. Many of the loans that are supposedly interest free incur social obligations that are difficult to quantify economically. There are few, if any, as lucrative economic opportunities for investment as moneylending in rural Bangladesh.

The provision of credit is as important as a mechanism for ensuring social control as it is as a means of generating wealth. Any analysis of economic behaviour must take account of social organisations; the major forms of which are: household or paribar, the homestead or bari (a collection of households) and the lineage or samaj. The household, usually comprising of a nuclear family, are those who regularly eat together. The largest social organisation is the lineage and as such it marks the social and economic horizon with the outside world. It is not so much the case that resources are obtainable within the lineage at much below their market price - although they usually are, there are cases where they can be above - rather, it is that these social organisations based on kinship and marriage function in ways something akin to a "welfare state": providing some insurance against unemployment, illness and starvation for poorer members. The provision of benefits to needier members often involves the provision of resources other than cash. So, for example, a man may be allowed to sharecrop land instead of being given a cash handout to buy rice. It is important, however, to realise that lineages and homesteads per se have no resources, it is the richer members who actually provide the resources. In return for this security the member gives his political support and social obedience to the lineage. The strength of the internal cohesion is crucial to the lineage in its dealings with local political institutions and state organisations. It is through such dealings that the resource base of its members - usually the richer, stronger ones - may increase. The importance of social organisation in distributing resources is discussed later in section 2.7 in analysing the distribution of tractor users.

The relationship between social organisation and the provision of credit is very complex. For example the rate of interest charged is dependent on many factors, including the opportunity cost of the principal lent and the degree of risk involved in lending. However whether the maximum rate of interest is charged depends on other sociological and economic considerations.

2.5: Cattle Ownership and Sharecropping

The latent consequences of draught animals are those effects that may be attributed to draught animals, but are not intended, as opposed to those manifest consequences that are intended and recognised by all. For example, a manifest consequence of draught animals is land preparation. An example of a latent consequence is the extent to which ownership of draught animals determines who shall be a sharecropper. There are two major latent consequences of draught

animal power:
(1) in determining who shall sharecrop, and
(2) in promoting land accumulation.
These will not be analysed separately.

Table 2.13 demonstrates that there is a close link between cattle ownership and sharecropping. Moreover, the vast majority of those who share crop in but do not own cattle, sharecrop in a relatively small amount of land. It is clear that an important attribute of being a sharecropper is cattle ownership. Cattle ownership, however, appears not to be a sufficient condition to be a sharecropper; some cattle owners are still frustrated in obtaining land for sharecropping.

TABLE 2.13: THE RELATION BETWEEN CATTLE-OWNING AND HOUSEHOLD CATEGORY

	Non-Owners	Owners	Total
Owner Cultivators	68	48	116
Sharecroppers	18	89	107
Cultivator/Landlords	37	30	67
Landlords	29	-	29
Others	3	11	14
TOTAL	155	178	333

Two-thirds of the landlords who sharecrop out land are landlord/cultivators. It is a difficult and complex conundrum as to why they prefer to sharecrop out their land to other cattle owners rather than either increase their own cattle holding and cultivate, or at least supervise the cultivation of all their land.[1] Three tentative suggestions may be made. Firstly, animals are a risky asset, because of their vulnerability to disease - most serious cattle diseases are endemic in Bangladesh - and to cyclones. Cultivators may prefer not to hold too many assets in such a risky form. Secondly, the cost of animal upkeep is relatively expensive and becoming more expensive as the availability of free grazing diminishes. The third, and possibly most important reason, concerns the amount of investment sharecroppers are prepared to make in land preparation. As Section 3.2 shows, smaller farmers obtain higher yields and cropping intensities than larger farmers. It may well be worthwhile to sharecrop land out to someone who is trying to maximise his production from limited resources than to cultivate the land oneself. The importance of draught animals in determining who is to be a sharecropper is clear. What is not so clear is whether landlord cultivators sharecrop out their land because of draught power or draught power management constraints and whether they sharecrop out for some other reason but select sharecroppers who have a proven capacity to cultivate the land; that is, they own cattle. As has already been pointed out, the tractor service was unreliable, and as a result it appears that no cultivator ceased

[1]For an in-depth analysis of this point, see Mettrick, 1971.

TABLE 2.14: DISTRIBUTION OF PLOTS BY ORIGIN OF ACQUISITION

Origin of Acquisition	Mechanised Village No.	%	Non-Mechanised Village No.	%	Total No.	%
Inheritance	666	(78.5)	1563	(84.9)	2229	(82.8)
Gift[1]	35	(4.1)	36	(2.0)	71	(2.6)
Purchase	105	(12.4)	222	(12.1)	327	(12.2)
Government Settlement	39	(4.6)	4	(0.2)	43	(1.6)
Mortgage	1	(0.1)	2	(0.1)	3	(0.1)
Others	2	(0.2)	14	(0.8)	16	(0.6)
TOTAL	849		1841		2689	

Source: Sociological Survey. [1]Gift usually through marriage

TABLE 2.15: DISTRIBUTION OF HOUSEHOLDS PURCHASING LAND BY LAND AREA OWNED AND RATE OF INCREASE OF LANDHOLDING

Land Area Owned (Acres)	Households	Holdings Increased		Land Bought		Percentage Increase in Landholding			
	No.	No.	%	No.	%[1]	0.01-5.00	5.01-10.00	10.01 +	Others[2]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
0.01-1.00	114	16	14.0	10	8.8)	4	2	2	2
1.01-2.00	70	24	34.3	15	21.4) 13.6	6	2	4	3
2.01-3.00	51	20	39.2	16	31.4)	10	2	2	2
3.01-4.00	29	18	62.1	15	51.7) 38.8	9	2	3	1
4.01-5.00	13	8	61.5	5	38.5)	3	1	1	
5.01-6.00	12	9	75.0	9	75.0)	5	2	1	1
6.01-7.00	7	4	57.1	4	57.1)	2	1	1	
7.01-8.00	2	2	100.0	1	50.0)	1			
8.01-9.00	10	7	70.0	6	60.0) 54.5	4	1		1
9.01-10.00	4	4	100.0	1	25.0)	1			
10.01+	18	12	66.7	10	55.6)	7	2	1	
TOTAL	330	124	37.6	92	27.9	52	15	15	10

[1]Land bought as percentage of land originally inherited. [2]Households buying but inheriting no land.

TABLE 2.16: DISTRIBUTION OF HOUSEHOLDS PURCHASING LAND BY LAND AREA INHERITED

Land Area Inherited (Acres)	Households	Holdings Increased		Land Bought		Percentage Increase in Landholding			
	No.	No.	%	No.	%	0.01-5.00	5.01-10.00	10.00 +	
0-.01	135	16	11.9	10	7.4	-	-	-	10
.01-1.00	145	28	19.3	21	14.5)	5	6	10	
1.01-2.00	74	25	33.8	15	20.3)	7	5	3	
2.01-3.00	51	17	33.3	14	27.5) 21.8	12	1	1	
3.01-4.00	21	10	47.7	8	38.1)	8			
4.01-5.00	12	7	58.3	6	50.0)	5	1		
5.01-6.00	5	2	40.0	1	20.0)	1			
6.01-7.00	6	3	50.0	3	50.0)	3			
7.01-8.00	7	7	100.0	6	85.7) 50.0	5	1		
8.01-9.00	4	1	25.0	0	0.0)	0			
9.01-10.00	1	1	100.0	1	100.0)	1			
10.01+	13	7	53.9	7	53.9)	5	1	1	
TOTAL (All)	474	124	26.2	92		52	15	15	

Source: Sociological Survey

sharecropping out and started to hire-in tractors so as to cultivate the land himself. However, given the fact that so many landlords do cultivate at least part of their landholdings, there is a high probability that mechanisation, as in other parts of S. E. Asia, will displace sharecroppers by diminishing the need for land preparation by draught animals, as the desire for more income, and/or the ability to manage machines increase. A reduction in the need for draught animals could erode the need for sharecroppers to provide them. This would have the effect of squeezing the sharecroppers and polarising the society, on the one hand, into labourers and owner cultivators who are also labourers, and on the other, owner cultivators hiring labour in with a small residual group of sharecroppers, sharecropping small parcels of land given by landowners who have some social responsibility for their welfare.

The problem is not one of access to tractors for sharecroppers. Ironically, during the survey when one of the publicly-owned tractors was made specifically available to the panel of farmers in the mechanised village the amount of land they sharecropped in increased. This was because they had access to an alternative capacity for land preparation, that was cheap (see Section 3.4) and very unequally distributed (see Section 2.7). Ensuring that sharecroppers and cultivator-landlords had equal access to tractors would do little to prevent the displacement of sharecroppers if the cultivator landlords decided they could cultivate the land themselves using tractors.

For sharecroppers, the tractor does not just threaten the amount of land available for sharecropping; it also threatens their ability to continue as cattle owners. As stated earlier, cattle ownership enables a cultivator to be eligible for land sharecropped out. In addition though, the cultivator is dependent on the straw and crop residues from that land. More than half of the cattle owners who own less than 3.5 acres of land, sharecrop in. The loss of sharecropped land could threaten the ownership of draught animals, as cattle owners lose the straw and crop residues, which they once had from land they sharecropped. This would have the effect not just of sharecroppers becoming owner-cultivators, left with only their own (small amount of) land, but also of sharecroppers becoming owner-cultivators who do not own draught animals. To be both cattleless and near landless is to become a member of the most vulnerable category of cultivators, in danger of becoming landless. Any displacement of sharecroppers could be accompanied by a rapid decline in the number of animals and a corresponding increase in the demand for tractorisation.

2.6: Cattle Ownership and Land Acquisition

There are several problems in trying to determine the role of cattle ownership in enabling households to acquire land. A thorough analysis of land transfers requires consultation of records and deeds in local land offices; such research was not practicable. The following discussion is based on farmers' interviews concerning land transfers without any verification from land office records. Another problem concerns the sensitive nature of land transfer, farmers are reluctant to discuss how land was acquired, especially where it involves sale or forfeiture due to failure to meet mortgage requirements. Table 2.14 shows how plots were acquired.

TABLE 2.17: HOUSEHOLDS WHICH HAVE LOST[1] AND SOLD LAND, BY LAND AREA OWNED

Land Area Owned (Acres)	House-Holds	Losses and Sales		Sales		Sales but no Purchases	
	No.	No.	%	No.	%	No.	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
0.01-1.00	114	21	18.4	10	8.8	10	8.8
1.01-2.00	70	12	17.1	8	11.4	5	7.1
2.01-3.00	51	8	15.7	6	11.8	2	3.9
3.01-4.00	29	7	24.1	3	10.3	1	3.5
4.01-5.00	13	1	7.7	1	7.7		
5.01-6.00	12	1	8.3	1	8.3		
6.01-7.00	7	1	14.3				
7.01-8.00	2	1	50.0	1	50.0		
8.01-9.00	10	3	30.0	2	20.0	1	10.0
9.01-10.00	4						
10.01 +	18	4	22.2	3	16.6	1	5.6
TOTAL	330	59	17.9	35	10.6	20	6.1

Source: Sociological Survey.

[1] Lost land refers to land lost through river erosion Sold land includes land forfeited through mortgage foreclosures.

TABLE 2.18: HOUSEHOLDS WHICH HAVE LOST AND SOLD LAND, BUT AREA OF LAND INHERITED

Land Area Owned (Acres)	House-holds	Losses and Sales		Sales		Sales but no Purchases	
	No.	No.	%	No.	%	No.	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
0	135						
0.01-1.00	145	19	13.1	16	11.0	15	10.3
1.01-2.00	74	12	16.2	9	12.7	5	6.8
2.01-3.00	51	13	15.0	6	11.8	3	5.9
3.01-4.00	21	9	42.9	5	23.8	2	9.5
4.01-5.00	12	3	25.0	1	8.3	1	8.3
5.01-6.00	5	1	20.0	1	20.0		
6.01-7.00	6	1	16.7				
7.01-8.00	7	6	85.7	3	42.9		
8.01-9.00	4						
9.01-10.00	1	1	100.0				
10.00 +	13	2	15.4	2	15.4	2	15.4
TOTAL	474	85	17.9	43	9.1	28	5.9

Source: Sociological Survey.

Inheritance is the major source of land, followed by purchase, gift and government settlement. Whereas farmers are reluctant to admit that land has been lost through mortgaging, it appears that those acquiring land through such means are even more reluctant to say so. The amount of land acquired through mortgaging is probably underestimated in Table 2.14. So during the following discussion it must be borne in mind (1) that land bought refers both to land received as a result of mortgage foreclosure as well as to land acquired through outright sale, and (2) that the area of land bought was not verified at the local land offices.

Land is viewed as the most secure of all possessions: guarantee not only of income but also of a secure income. It is the most obvious source of secure investment and ownership brings status and prestige. In whatever ways wealth may be accumulated, whenever possible it is invested in land - the ultimate expression of wealth. The ownership of draught animals and the hiring-out of draught animals is but one potential way of accumulating wealth. In order to illustrate clearly the relationship between draught power and land acquisition, other means of land acquisition must be discussed and controlled for.

Table 2.15 shows that a third of all landholders have increased the size of their landholding from the area they inherited. Col. (3) shows the distribution by the area of land that they own of all households who have acquired land by whatever means. Col. (5) shows the distribution of those who have bought land since they received their inheritance. Cols. (7)-(9) show the distribution of the percentage increase in landholding on an annual basis. This is simply the land area bought expressed as a percentage of the land area inherited divided by the number of years since the inheritance was received. The bigger percentage increases are among the smaller farmers. This however reflects the small amount of land they received from their inheritance rather than larger purchases than the bigger farmers'.

Table 2.15 shows it tends to be more often the bigger landowners who increase in size than small landowners and that more of the bigger landowners buy land than smaller landholders. Of households owning land: 13.6% of those owning less than 2 acres had bought land; 38.8% of those owning more than 2 acres but less than 4 acres had bought land; and 54.5% of those owning more than 4 acres had bought land. Statistically there is a highly significant difference between the incidence of land buying among landowners owning more than four acres as compared to other landowners.

Table 2.16 distributes households buying land by the area of land they originally inherited. Considering <u>all</u> households: 7.4% of landless households bought land; 21.8% of all households inheriting 4 acres or less had bought land; while 50.0% of all households inheriting more than 4 acres had bought land. These are signifiicant differences. Tables 2.17 and 2.18 are concerned with land that has been lost or sold. The major cause of land being lost is river erosion. In these Tables column (3) contains the number of households who have lost or sold land for whatever reason; column (5) contains the number of households who have sold land; while column (7) contains the number of households who have sold land and have <u>not</u>

TABLE 2.19: DISTRIBUTION OF HOUSEHOLDS BUYING LAND BY LAND AREA OWNED AND BY ECONOMIC CATEGORY: CULTIVATOR, LANDLORD AND EXTRA-AGRICULTURAL INCOME

Land Area Owned (Acres)	All Households	HOUSEHOLDS WITH EXTRA-AGRICULTURAL INCOME				LANDLORDS				CULTIVATORS			
		Total		Households Bought Land		Total		Households Bought Land		Total		Households Bought Land	
		No.	Nos. Acq. Land[1]	No.	%	No.	Nos. Acq. Land[1]	No.	%	No.	Nos. Acq. Land[1]	No.	%
0.01-1.00	114	72	14	10	13.9	7	1	0	-	35	1	0	-
1.01-2.00	70	30	14	8	26.6	9	3	2	22.2	31	7	5	16.1
2.01-3.00	51	20	8	4	20.0	12	3	3	25.0	19	9	9	47.4
3.01-4.00	29	17	12	10	58.8	4	1	1	25.0	8	5	4	50.0
4.01-5.00	13	3	3	3	100.0	3	0	0		7	5	2	28.6
5.01-6.00	12	6	5	5	83.3	2	1	1	50.0	4	3	3	75.0
6.01-7.00	7	4	2	2	50.0	3	2	2	66.7	1	0	0	-
7.01-8.00	2	2	2	1	50.0								
8.01-9.00	10					6	4	4	66.7	4	3	2	50.0
9.01-10.00						2	2	0	-	2	2	1	100.0
10.00 +	18	4	4	4	100.0	13	7	5	38.5	1	1	1	100.0
Total	330	158	64	47	29.8	61	24	18	29.5	112	36	27	24.1

Source: Sociological Survey

TABLE 2.20: DISTRIBUTION OF CULTIVATOR HOUSEHOLDS BUYING LAND BY LAND AREA OWNED AND ACCESS TO DRAUGHT POWER

Land Area Owned (Acres)	All Households	HOUSEHOLDS NOT OWNING CATTLE				CATTLE OWNERS							
						Owners of Surplus Draught Power				Owners of Insufficient or Adequate Draught Power			
		No.	Nos. Acq. Land[1]	Bought Land No.	%	No.	Nos. Acq. Land[1]	Bought Land No.	%	No.	Nos. Acq. Land[1]	Bought Land No.	%
0.01-1.00	35	14	0	0	-	4	0	0	-	17	1	0	-
1.01-2.00	31	8	1	1	12.5	10	3	2	20.0	13	3	2	15.4
2.01-3.00	19	3	1	1	33.3	7	5	5	71.4	9	3	3	33.3
3.01-4.00	8					3	3	2	66.7	5	4	2	40.0
4.01-5.00	7					1	1	0	-	6	2	2	33.3
5.01-6.00	4					2	2	2	100.0	2	1	1	50.0
6.01-7.00	1									1	0	0	-
7.01-8.00													
8.01-9.00	4					1	1	1	100.0	3	2	1	33.3
9.01-10.00	2					2	2	1	50.0				
10.00 +	1					1	1	1	100.0				
Total	112	25	2	2	8.0	31	17	14	45.16	56	17	11	19.1

Source: Sociological Survey.

[1] Nos. of households who have acquired land in addition to inheritance - whatever the method of acquisition.

been able to replace any part of it. Including those households who have become landless as a result of losing or selling their land, 17.9% of all households have lost or sold land compared to 27.9% of households who have acquired land in addition to that which they inherited (Table 2.15). Increasing fragmentation and the bringing into cultivation of char land, that was once used for grazing, are the major reasons why there are more households acquiring land than there are households losing or selling land. Ignoring land lost through erosion, 35 households (12.7% of all households who inherited land) have sold land. The threat of river erosion is a major reason for some farmers selling land, especially for big landowners: this was the case with six out of the eight farmers who own more than four acres and sold land. (Table 2.17, column (5)). Of the 35 households who have sold land, 15 (34.9%) have been able to replace some or all of that land. This means, as Table 2.18, column (7) indicates, 28 households who have sold land have not acquired land so as to be able to replace it. All those 28 households sold land for cash for food and/or to pay off debts. Two (7.7%) of those households who inherited more than four acres have sold land and not replaced it, while 29[1] (9%) of those households who inherited four acres or less have sold land and not replaced it. Cell size is too small to allow a statistical test of significant difference. With such small numbers odd individual whims are impossible to differentiate from wider sociological or economic phenomena. Given that it is not statistically possible to demonstrate that smaller landowners are selling land more frequently than bigger farmers, it is correct to say in absolute terms about 10% of all small landowners have sold part or all of their inheritance. As was shown earlier large landowners are buying land more frequently than small landowners. The larger the landowner, the more likely he is to buy land.[2]

Although size of landholding is the most important factor in determining which households increase their land sizes and in particular which households buy land, there are other factors that need to be taken into account. Table 2.19 differentiates all landowning households into three major categories (1) those with incomes additional to their earnings from cultivation; (2) landlords; (3) cultivators. The profits or earnings made by group (1) from extra-agricultural sources are often invested in land. As Table 2.19 shows there are 158 households (48% of all households owning land) who have a source of extra-agricultural income; and that 30% of those households have bought land. These extra-agricultural income sources arise from trading; agricultural processing; fishing; crafts such as carpentry; house construction and boat building; traditional occupations such as village doctor, religious functionaries; government service, including

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[1]Includes three additional households - who have acquired some land but not as much as they sold - in addition to the 26 households included in Table 2.18, column (7).

[2]As we shall see below in Section 3, such a redistribution of land from small to larger landowners represents not just an increase in landlessness but also a fall in productivity.

teachers and tax collectors. All those who own less than one acre of land and who have bought land have an extra-agricultural income. Indeed over half of all households who have bought land have an extra-agricultural income source.

Group (2) includes landlord-cultivators and landlord-sharecroppers. As Table 2.19 indicates 61 households (35% of the households solely dependent on agriculture) sharecrop-out some or all of their land, and that 18 (29.5%) have bought land. Households sharecropping out land account for 20% of all households buying land.

Those with an extra-agricultural income, or who are landlords, do not buy land more or less frequently than cultivators.[1] They have been excluded from further analysis because for these categories control over draught power is not necessarily an important means of accumulating wealth, and because the relation between draught power and land acquisition will not be the objective of study.

There are 112 households (33.8% of total landed households) who cultivate all their own land as well as possibly sharecropping in an additional acreage and who do not have any extra income sources (Group(3)). As can be seen from Table 2.19, 24.1% of this cultivator category have purchased land. By concentrating solely on cultivators it is now possible to examine:
(1) the relationship between cattle ownership and land purchase, and
(2) the relationship between hiring-out cattle and land purchase.
Table 2.20 distributes cultivator households into three categories: (i) households not owning cattle; (ii) owners of surplus draught power; and (iii) owners of insufficient or adequate draught power. Households in category (ii) do not hire-in any draught power but all hire-out draught power. Category (iii) includes those households who are self-sufficient for draught power - they neither hire-in nor hire-out their draught animals - and those households who hire-in draught power. As Table 2.20 demonstrates only two (8.0%) of the 25 households who do not own cattle have bought land compared to 25 (28.7%) of the 87 households who do own cattle. A statistical test shows a significant difference[2] between the frequency of land purchase among cattle-owning households as opposed to households who do not own cattle. Cattle owners buy land more frequently than cultivators who do not own cattle. Caution, however, must be exercised in interpreting this result. Although cattle ownership and land purchase have a significant relationship, the intensity of association is weak.[3] This weakness is primarily due to the fact that the majority of cattle-owners (71.3%) have not bought land. Cattle ownership does not necessarily enable a household to buy land. Cattle ownership and land purchase may be only different sides of the same coin: both may be indicators of a similar and particular level of productive capacity or wealth. Is cattle ownership then a concomitant of land purchasing?

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[1] Chi-square test showed no significant difference at 5% level.

[2] Chi-square test showed relationship statistically significant at 5% level.

[3] Coefficient of association = 0.226.

One way of trying to answer this question is isolate similar size landholdings and then analyse cattle ownership and land purchase. If the analysis is limited (i) to those households owning at least one acre - no cultivator owning less than one acre has bought land; and (ii) to those households owning less than three acres - all cultivator households owning more than three acres own cattle; then the influence of the size of landholding on land purchase is kept to a minimum. Given these two constraints, the proportion of cattle-owning households buying land is still higher than that of households not owning cattle: two (18.2%) of the eleven households not owning cattle have bought land, compared to 12 (30.8%) of the 39 cattle-owning households. Cell size is too small to allow a test of significant difference.

If we consider land purchase with size of area inherited rather than owned, and the analysis is limited to those households inheriting less than three acres (all households inheriting more than three acres own cattle), then 15 (21.7%) of the 69 households owning cattle have bought land compared to the 2 (8%) of 25 households who do not own cattle. There is no statistical significance in this difference.[1]

Care must of course be taken in interpreting all these figures. Even allowing for the fact that both households with extra-agricultural incomes and households who sharecrop out land are already excluded, there are still many ways in which households could accumulate wealth to buy land; for example a cash inheritance or financial gift through matrilineal or affine relations. Idiosyncratic circumstances are always going to allow a few households to purchase land. Such circumstances are randomly scattered over all types of households. Thus, though the evidence shows cattle ownership to be associated with land purchase, for certain sizes of landholding the results are statistically inconclusive.

The relationship between cattle ownership and land purchase can be further investigated by an examination of the relationship between households hiring-out cattle and the incidence of these households buying land. In Table 2.20 cattle owners are included in the "surplus draught power" category if they hire-out their cattle; as the extent of their hiring-out was not measured the category includes both households who regularly or only occasionally hired-out. As Table 2.20 reveals 14 (45.2%) of the 31 households with surplus draught power have bought land compared to only 11 (19.6%) of the 56 households with adequate or insufficient draught power. A test of significance shows the difference to be statistically significant[2]: the frequency of households hiring-out cattle who buy land is greater than the frequency of the other cattle-owning households buying land. The intensity of association is weak. This is because (i) the majority of households (54.8%) who own surplus draught power have not purchased land, and (ii) almost 20% of the households with no surplus draught power have also bought land. Examination of Table 2.20 shows that 20 out of 87

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[1]The observed difference in proportion is less than two standard errors of difference.

[2]Chi-square = 6.4, significant at 5% level. Coefficient of association = 0.174.

(30%) of cattle owners with adequate or insufficient draught power own less than one acre, and that these cattle owners - in common with all cultivators who own less than one acre - have purchased no land. If all cattle owners owning less than one acre are excluded, the proportion of cattle owners (52%) with a draught power surplus buying land is still greater compared to other cattle owners (29%), and the difference is statistically significant.[1] The 'rate of increase' also differs between cattle owners: owners of surplus draught power are increasing their landholding through land purchase at 4.5% per annum compared to 1.06% for other cattle owners. This difference, in statistical terms, is highly significant.[2]

To sum up therefore, a quarter of landed households in the villages studied have acquired additional land and almost a fifth of these households have lost or sold land. Bigger landowners acquire land more frequently than others through land transfer. This transfer of land is not a new phenomenon. It has always taken place, though whether at its present rate is debatable. There are several ways in which a household can produce a sufficient surplus, over and above subsistence requirements, to enable it to purchase new factors of production such as land and draught power. With regard to those who produce a surplus through cultivation, land is the most important resource. For the vast majority of households, between two and four acres are needed to be owned and cultivated to begin to create a surplus. At these marginal levels of wealth accumulation it would be surprising if the ownership and hiring-out of draught power - the second most important factor of production - did not become important. A thorough examination of the relationship between draught animal power and land accumulation would require a detailed analysis of: (1) the differences in costs and levels of production between draught animal owners and hirers; (2) the circumstances under which draught animal owners are prepared to hire-out their draught power and forego further increases in the cultivation of their own land; and (3) how the choice is determined by those with surplus draught capacity, to either sharecrop in land or hire-out cattle. In the absence of other evidence, the statistical results show land is being accumulated by, among others, those who own the means of land preparation and those who hire-out these means. This has an important implication: any increase in draught power - be it from improvements in cattle stock or from the introduction and further extension of mechanical power - will enhance the potential of those who either own or come to control (i.e. brokers) this increase in draught power further to augment their landholdings.

2.7: <u>Access to Tractors</u>

Tractor use is <u>not</u> associated with only larger landholdings. Table 2.21[3] clearly illustrates this. The lack of any significant positive correlation between larger landholdings and tractor use is surprising and is due to two factors:

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[1]Chi-square = 3.8, significant at 5% level.

[2]The difference in sample means is four times the standard error of difference.

[3]Note that this Table related to the Sample of the Core Survey.

TABLE 2.21: DISTRIBUTION OF TRACTOR USERS[1] OVER TIME AND LAND AREA FARMED

Land Area (Acres)	Nos. of House-holds	Nos. of Culti-vators	TRACTORS USED									
			73/74		74/75		75/76		76/77		77/78	
			No.	%	No.	%	No.	%	No.	%	No.	%
0	73	7	3	43	-	-	-	-	1	14	3	43
0.01-1.00	67	42	14	33	15	36	17	40	21	50	26	62
1.01-2.00	37	33	9	27	9	27	15	39	12	30	12	33
2.01-3.00	13	7	2	29	3	43	4	57	3	43	5	71
3.01-4.00	15	10	3	30	3	40	3	30	4	40	4	40
4.01 +	19	11	4	36	3	27	5	45	4	36	4	36
Total	224	110	35	32	33	30	42	38	45	41	53	38

[1] 'Tractor use' was determined by whether a cultivator hired a tractor - irrespective of the numbers of times hired and the amount of land the tractor cultivated. In fact, tractors tended to be hired once and only a small portion of each person's land was cultivated by tractor.

Source: Core Survey.

(1) the low level of the hire price charged, and
(2) tractors are distributed along lines of kinship and political affiliations.

Even with extraneous payments the price of hiring a tractor was well below the cost of hiring draught animals. Every farmer was financially able to hire a tractor. With the price mechanism allowing equal access to a resource that was scarce, distribution was likely to be determined by sociological factors. The way the schemes were organised to distribute tractors to would-be hirers encouraged a 'brokerage' system to develop which reinforced and was reinforced by, the sociological forces of family ties, network relationships and political affiliations.

The system devised for distribution of tractors was a scheme consisting of a scheme manager and a number of farmers. In advance of a particular ploughing season, the scheme manager submitted a map showing the location of the scheme members' plots and a list of scheme members to the officer in charge of the hire station. All schemes then went before a selection committee. Given the low price of tractors, demand was high and this meant that some schemes were invariably rejected. The scheme manager had an important function in lobbying for his scheme: this may have involved certain entertainment expenses as well as the employment of any political pressure that the scheme manager could mobilise at a local level. However, even with the scheme accepted there was no guarantee of a tractor: tractors were provided as and when they were available. The pressure to get schemes accepted led to optimistic assessments of the number of tractors the hire station was capable of supplying and, more importantly, keeping supplied through-out the ploughing season. Inevitable breakdowns occurred postponing schemes and eventually leading to cancellations. If the scheme manager was reasonably sure his accepted scheme would receive a tractor, he collected the hire fees from the scheme's members and deposited the money in the bank. He then gave the certificate of payment to the unit manager. The relationship between the hire station officials and the scheme manager was crucial.

As already described in Section 2.4, there are three major social organisations within a village community: the household, the homestead, the lineage. In the mechanised village there were three major lineage groupings based on cognate relations; each had its own mosque, and membership of the lineage group could be recognised through which mosque a person attended. Through cognatic relationships alone the samajs consisted of some twenty households each - about 30% of the total household population. However, attached to these three main clusters of households were other households more or less loosely attached through political, neighbourhood and affine ties.

During the period 1973-78 when the tractor service was functioning at its highest level of operation, the station was used regularly[1] by 27% of the farmers in the mechanised village. More than half of the homesteads engaged in cultivation in two of the lineage groupings hired tractors regularly. Tractors were never used in the other major lineage. Tractor use by the two lineages accounted for 60% of all tractor use. Tractor use outside the three lineages reached just under 20% of non-lineage households.

There were two major tractor schemes throughout the 1973-78, both managed by a senior member of the two lineages involved. It was difficult to establish why the third major social and political grouping in the village had never formed a relationship with the tractor station, but failure to do so had deprived the whole group of cheap land preparation. It is clear that membership of, or access to, the appropriate lineage was an important determinant in who hired tractors. The tractor hire station represented a new resource and as such meant a new source of potential power and social status. In order to tap this source, control had to be attained over the relationship that linked the village to the station. Using their lineage bases two individuals were able to set up and control linkages between the hire station and their lineage - and through their lineage to other homesteads and households in the village. In terms of the control within the lineage it meant an increase in its internal cohesion - compliant membership could be used as a basis if access to the new resource was to be assured. Control over the new resource also meant a strengthening, and possible increase, in prestige of the lineage itself within the village. For the individual member who acted as the broker, it also reinforced his social and political position within the lineage.

Even though, then, tractor use was not associated with the size of landholdings access to tractors was still by no means equal. Such inequality means that the benefits of tractors (in terms of their cheapness) did not necessarily accrue to those who needed tractors the most - those not owning draught animals.

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[1]Regular use here means that a farmer hired a tractor to plough all or part of his land, in at least three years of 1973-78 period.

CHAPTER 3: THE AGRICULTURAL SYSTEM

3.1: Cropping Patterns

Agricultural activity in the delta, like elsewhere in Bangladesh, is determined by the monsoon, which brings heavy rainfall from June to September. As Figure 3.1 shows there are three major seasons:
(a) winter, from November to February,
(b) summer, from March to May, and
(c) a wet season from June to October.

A report of the Soil Survey Project, prepared by FAO describes the area as "Highly silty calcareous alluvium. Mainly slightly saline in dry season. Most cultivated soils have a ploughpan and permeability through the finely stratified silty alluvium is slow". (Ahmed, 1976, pp. 77). The District Gazetteer states "The soil is a rich alluvial deposit and requires generally little preparation for cultivation" (Khan, (Ed) 1977, p. 85).[1]

The staple crop is rice. The major crop is aman, grown on 97% of the cultivated area in the survey. The other rice crop is aus, grown on 43% of the cultivated area. In the winter or rabi season, pulses and two major cash crops, chillies and groundnuts, are planted, in addition to other vegetables (onions, garlic, sweet potatoes and spices).

More than half the area is double-cropped; the cropping intensity[2] for the survey area is 165 (Figure 3.2). This is despite the fact that there are no irrigation facilities. The saline nature of the water in winter, as well as the increase in salinity of the soil through capillary action, appears to prevent the development of any assured irrigation source.

Agricultural production is totally dependent on being rainfed. In order to optimise the rainwater brought by the monsoon, the harvesting of aus and the transplanting of aman take place at the height of the monsoon. Rajashail, Kajulshail, Modhumalati are the main varieties of aman cultivated. They are sown in July to August, transplanted one month later, and harvested in November and December. Modern varieties (IRRI) of rice are not grown in this season. However, IRRI rice, along with more traditional varieties, are grown in the aus season. IRRI rice (major varieties: IR-4 and IR-8). introduced in the early seventies, and traditional aus (Borlam, Moricha and Jhalabishna) each account for half the area cultivated in the aus season. While IRRI varieties are occasionally transplanted in this season, most of the aus is sown directly into the field, the traditional aus usually being broadcast and the IRRI aus dibbled. The sowing takes place in March and April and the harvesting in July

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[1] A physical description of the survey area is given in Appendix B.

[2] Cropping intensity is defined as the relationship between the net cropped area and the total operated area.

FIGURE 3.1: MEAN MONTHLY RAINFALL (Maijdi Court, 1902-61) and MEAN TEMPERATURE (Maijdi Court)

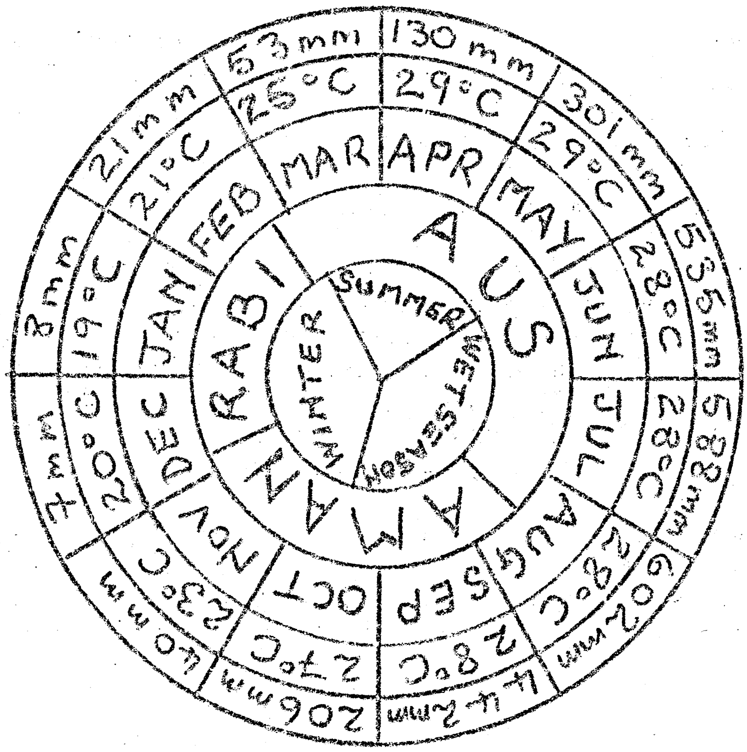


FIGURE 3.2: DISTRIBUTION OF CROPPING INTENSITY

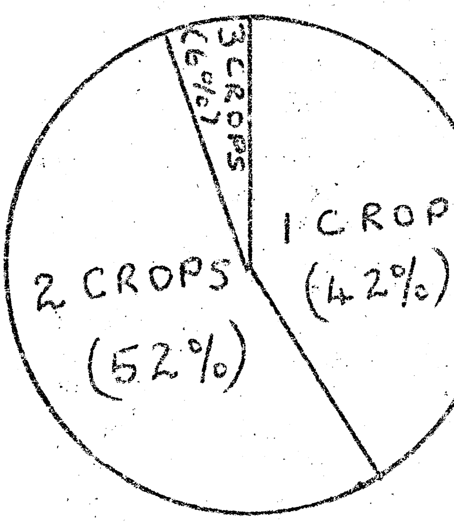


FIGURE 3.3: DISTRIBUTION OF MOST COMMON ROTATIONS

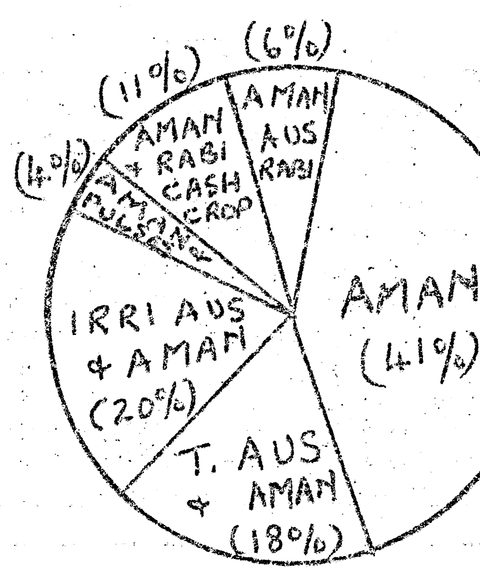


TABLE 3.1: A COMPARISON OF SELECTED MEASURES OF AGRICULTURAL BEHAVIOUR FOR VARIOUS CATEGORIES OF LAND CULTIVATED[1]

Acres:	< 2	2 -4	> 4
Number of Farmers	24	15	21
Cropping Intensity	183	170	164
Cropping Intensity of Non-Char Land Area	183	176	181
Mean Nos. of Animal[2] days Ploughing Aman	10.2	8.5	4.8
Mean Total Labour Days All Operations for Aman	39.9	45.8	23.0
Aman Yield (Maunds/Acre)	19.0	16.7	17.0
Mean Nos. of Animal[2] days Ploughing Aus 1979	11.7	12.2	10.0
Mean Total Labour Days All Operations for Aus 1979	66.2	74.1	54.3
Yield Traditional Aus 1978 (Maunds/Acre)	17.3	19.6	17.8
Yield IRRI Aus 1978 (Maunds/Acre)	36.7	33.3	33.2

[1]Land cultivated = own land cultivated + sharecropped in land.

[2]Animal day measured as six hours.

Source: Weekly Survey

TABLE 3.2: COMPARISON OF SELECTED MEASURES OF AGRICULTURAL BEHAVIOUR FOR VARIOUS CATEGORIES OF CATTLE HIRERS AND OWNERS

	Cattle Owners Non-Hirers	Cattle Owners and Hirers	Non-Cattle Owners
Number of Farmers	26	9	25
Mean Land Area Owned (Acres)	5.47	6.40	1.65
Cropping Intensity	166	158	186
Mean Non-Char Area Cultivated (Acres)	4.94	4.06	1.62
Cropping Intensity of Non-Char Land Area	175	181	186
Mean Nos. of Animal[1] Days Ploughing Aman	7.2	6.3	8.9
Mean Total Labour Days All Operations for Aman	32.1	32.0	42.0
Aman Yield (Maunds/Acre)	15.8	18.7	19.3
Mean Nos. of Animal[1] Days Ploughing Aus 1979	12.9	9.7	8.3
Mean Total Labour Days All Operations for Aus 1979	59.5	70.1	65.1
Yield Traditional Aus 1978 (Maunds/Acre)	18.2	18.5	18.1
Yield IRRI Aus 1978 (Maunds/Acre)	32.6	35.9	35.6

[1]Animal day measured as six hours.

Source: Weekly Survey

and August. Pulses (the major varieties: Khesari, Mung, Mashkalai) are sown from the end of October onwards and harvested from February to mid-March. It is possible to grow aus-aman-pulses in one calendar year. The other major rabi crops are chillies, groundnuts and a variety of vegetables and spices. The vegetables and spices (and sometimes pulses) are inter-cropped. The chillies, are sown in seed-beds in October and are transplanted out after the harvesting of the aman crop; the crop is harvested in May and June. Groundnut production which was limited in the past, has been extended through Government schemes. Planted in October and November, it is harvested in March and April. The growing of chillies and groundnuts competes with the cultivation of aus. The distribution of cultivated land during the period when aus and rabi crops compete is as follows: 38.3% growing IRRI aus; 37.3% growing traditional aus; and 23.9% growing chillies and groundnuts. Permanent crops account for little over 1% of the total land area cultivated, yet they are an important source of cash for farmers. The two most important are pan (betel vine) and the betel nut. The former is the major crop. Pan is a classic example of a low volume, high value crop; despite being cultivated in a remote rural area, the transport cost relative to total cost when marketed is low. The vine is grown on a raised bed, enclosed within a frame of grass and reeds, some seven feet high. The vines are trained up sticks and require considerable labour to earth up and weed. It can be continually cropped for three years and can be highly profitable.

The results of the soil survey project of Bangladesh (1971) state that the general cropping pattern in the area is "mainly transplanted aman". Aus and rabi crops (especially chillies) are also grown on some higher parts (as qv Ahmed, 1976, p. 76). Official estimates for the same thanas from which the sample data were drawn put the cropping intensity at 118 (MDA, 1975, pp. 32-52). Using the same definition of cropping intensity, the cropping intensity for the survey was 165. The situation is changing. Much of the increase in cropping intensity has come about since the cyclone. Despite the loss of draught animals in 1971, cropping intensities, and with them agricultural production, have increased, and draught animals have played a critical role in this. How much of this increase, if any, is due to tractorisation is open to conjecture.

3.2: Land Preparation: Small and Large Farmers

The weekly survey provides evidence that there are differences between large landowning cattle owners and small landowning households who do not own cattle in a number of aspects of husbandry.

Table 3.1 differentiates the farmers in the weekly survey by area of land they cultivate. A comparison of those cultivating less than two acres with those cultivating more than four acres shows that yields, cropping intensities and the level of certain resource inputs - the number of animal-days involved in land preparation and the total amount of labour - are all higher for smaller cultivators. Table 3.2 compares the weekly survey farmers categorised by their ownership and hiring-in of draught animals: as can be seen yields and cropping intensities are higher for those not owning cattle. In addition, in the aman season those not owning cattle employed more cattle to prepare their land than those who owned cattle. These results, in most cases, are not conclusive as the differences are not statistically significant. However, what is important is that these figures show that cattle ownership is not associated with higher yields or cropping intensities. There are two major reasons for this: (1) households not owning cattle employ at least the same amount of draught animal power as cattle owners; and (2) households not owning draught animals employ more labour than cattle owners.

Table 3.3 compares the labour days per acre employed for the two major rice crops aman and aus. According to the weekly survey small cultivators employ almost 75% more man-days to cultivate aman and nearly 20% more man-days to cultivate aus, than big farmers. Table 3.4 compares the labour days per acre employed for aus and aman on the basis of cattle ownership and the hiring-in of draught power. Caution must be exercised in drawing conclusions from the Table because households not owning cattle and hence who hire-in their draught power requirements include not only cultivators with small acreages, but also larger landowners for whom agricultural cultivation is a secondary activity. Households in this latter sub-category have other major business interests or sharecrop out some of their land more or less supervising what land they cultivate, hiring-in draught power and labour when required. Table 3.4 shows that those without draught power employ 30% and 10% more labour to cultivate aman and aus respectively than those owning draught animals and who do not hire-in. It is, however, not simply a case of small farmers investing more of their own labour - which they do - but also of employing more - or certainly as much - casual labour as bigger farmers. In both the case of aus and aman small farmers employ a slightly higher proportion of casual to family labour compared to medium and larger farmers (Table 3.3). Consideration of the same Table shows that the proportion of casual to family labour is the same for all categories of farmers for sowing/transplanting, crop care and harvesting of aus and sowing/transplanting and crop care of aman. The time period to perform these tasks is very limited and there is very little opportunity for small farmers to increase yields and cropping intensities through their own labour. The fact that smaller farmers employ more casual labour for land preparation reflects their lack of cattle ownership: in most cases they are obliged to hire a man with a pair of draught animals. During the harvesting of aman where time is not so pressing, smaller farmers use proportionately more of their own labour than bigger farmers. While no doubt maximising the contribution their own labour can make to production, the high levels of productivity small cultivators strive to achieve can only be accomplished with the use of casual labour.

That those with the least land should be the more intensive cultivators is not surprising because the alternative for these cultivators, is an increase in poverty, misery, deprivation and hunger. However small cultivators in achieving the same or, in many cases, higher levels of resource inputs - compared to other large cultivators, often have to pay higher prices for these resources. With regard to draught power: the cost for smaller farmers is higher in that it must be greater than the opportunity cost to the owner of not hiring-out. Smaller farmers, it seems, pay more for cattle they hire compared to larger farmers. The cattle hiring rate is highly volatile. The cost of supply varies according to the cost

TABLE 3.3: LABOUR USE AUS AND AMAN SEASONS (MAN DAYS/ACRE)[1] BY LAND CULTIVATED

AMAN	ALL FARMERS		ACRES < 2.00		ACRES 2.00-4.00		ACRES >4.00	
	No.	%	No.	%	No.	%	No.	%
1. Land Preparation								
Permanent Labour	2.53	(50.2)	1.30	(20.7)	4.66	(74.8)	2.34	(77.5)
Casual Labour	2.51	(49.8)	4.98	(79.3)	1.57	(25.2)	0.68	(22.5)
Total Labour	5.04	14.7	6.28	15.7	6.23	13.6	3.02	13.2
2. Sowing Transplanting								
Permanent Labour	2.16	(13.1)	2.08	(10.3)	3.08	(12.8)	1.65	(16.9)
Casual Labour	14.38	(86.9)	18.17	(89.7)	20.98	(87.2)	8.14	(83.1)
Total Labour	16.54	48.2	20.25	50.7	24.06	52.6	9.79	42.6
3. Crop Care								
Permanent Labour	1.30	(64.4)	1.32	(58.7)	1.62	(68.5)	0.88	(62.9)
Casual Labour	0.72	(35.6)	0.93	(41.3)	0.75	(31.5)	0.52	(37.1)
Total Labour	1.02	5.9	2.25	5.6	2.37	5.18	1.40	6.1
4. Harvest								
Permanent Labour	3.35	(31.2)	4.53	(40.7)	4.09	(31.2)	1.68	(19.2)
Casual Labour	7.38	(68.8)	6.60	(59.3)	9.02	(68.8)	7.08	(80.8)
Total Labour	10.73	31.3	11.13	27.9	13.11	28.6	8.76	38.1
TOTAL PERMANENT LABOUR	9.34	(27.2)	9.23	(23.1)	13.45	(29.4)	6.55	(28.5)
TOTAL CASUAL LABOUR	24.99	(72.8)	30.68	(76.9)	32.32	(70.6)	16.42	(71.5)
TOTAL LABOUR	34.33	(100.0)	39.91	(100.0)	45.77	(100.0)	22.97	(100.0)
AUS[2]								
1. Land Preparation								
Permanent Labour	5.21	(74.2)	2.79	(37.8)	7.38	(89.8)	5.63	(94.0)
Casual Labour	1.81	(25.8)	4.59	(62.2)	0.84	(10.2)	0.36	(6.0)
Total Labour	7.02	10.9	7.38	11.2	8.22	11.1	5.99	11.0
2. Sowing/Transplanting								
Permanent Labour	7.64	(60.0)	6.91	(54.2)	9.52	(68.0)	6.77	(59.4)
Casual Labour	5.09	(40.0)	5.85	(45.8)	4.48	(32.0)	4.63	(40.6)
Total Labour	12.73	12.7	12.76	19.3	14.00	18.9	11.40	21.0
3. Crop Care								
Permanent Labour	19.57	(75.5)	19.02	(80.7)	24.13	(75.4)	15.63	(72.2)
Casual Labour	6.35	(24.5)	4.54	(19.3)	7.86	(24.6)	6.02	(27.8)
Total Labour	25.92	40.2	23.56	35.6	31.95	43.2	21.65	39.9
4. Harvest[3]								
Permanent Labour	1.92	(10.2)	2.70	(12.0)	1.75	(8.8)	1.36	(8.9)
Casual Labour	16.89	(89.8)	19.79	(88.0)	18.14	(91.2)	13.87	(91.1)
Total Labour	18.81	29.2	22.49	33.9	19.89	26.8	15.23	33.6
TOTAL PERMANENT LABOUR	34.34	(53.3)	31.42	(47.5)	42.78	(57.7)	29.39	(54.2
TOTAL CASUAL LABOUR	30.14	(46.7)	34.77	(52.5)	31.32	(42.3)	24.88	(45.8)
TOTAL LABOUR	64.48	(100.0)	66.19	(100.0)	74.10	(100.0)	54.27	(100.0)

[1] Man days measured in ten-hour days.

[2] Aus, combined traditional and IRRI Aus varieties.

[3] Figures calculated from 1978 Aus harvest, 1979 Aus harvest disrupted due to drought.

Source: Weekly Survey.

TABLE 3.4: LABOUR USE AUS AND AMAN SEASONS (MAN DAYS/ACRE)[1] BY ACCESS TO DRAUGHT POWER

AMAN	All Farmers		Cattle Owners Non-Hirers		Cattle Owners and Hirers		Non-Cattle Owners	
	No.	%	No.	%	No.	%	No.	%
1. Land Preparation								
Permanent	2.53	(50.2)	4.89	(97.6)	2.71	(63.5)	0.00	(0.0)
Casual	2.51	(49.8)	0.12	(2.4)	1.56	(36.5)	5.38	(100.0)
Total	5.04	(14.7	5.01	15.60	4.27	13.35	5.38	12.81
2. Sowing/Transplanting								
Permanent	2.16	(13.1)	3.40	(22.4)	1.68	(10.7)	2.23	(9.6)
Casual	14.38	(86.9)	11.76	(77.6)	14.09	(89.3)	20.99	(90.4)
Total	16.54	48.2	15.16	47.20	15.77	49.31	23.22	55.30
3. Crop Care								
Permanent	1.30	(64.4	1.46	(74.9)	0.96	(86.5)	1.10	(48.0)
Casual	0.72	(35.6	0.49	(25.1)	0.15	(13.5)	1.19	(52.0)
Total	2.02	5.9	1.95	6.07	1.11	3.47	2.29	5.45
4, Harvest								
Permanent	3.35	(31.2)	3.76	(37.6)	2.51	(23.2)	2.90	(26.1)
Casual	7.38	(68.8)	6.24	(62.4)	8.32	(76.8)	8.20	(73.9)
Total	10.73	31.3	10.00	31.13	10.83	33.87	11.10	26.43
TOTAL PERMANENT LABOUR	9.34	(27.2)	13.51	(42.1)	7.86	(24.6)	6.23	(14.84)
TOTAL CASUAL LABOUR	24.99	(72.8)	18.61	(57.9)	23.12	(75.4)	35.76	(85.16)
TOTAL LABOUR	34.33	(100.0)	32.12	(100.0)	31.98	(100.0)	41.99	(100.0)
AUS[2]								
1. Land Preparation								
Permanent	5.21	(74.2)	8.06	(97.6)	5.61	(89.1)	0.00	
Casual	1.81	(25.8)	0.20	(2.4)	0.69	(10.9)	5.10	(100.0)
Total	7.02	10.9	8.26	13.89	6.30	8.98	5.10	7.83
2. Sowing/Transplanting								
Permanent	7.64	(60.0)	8.93	(72.8)	6.01	(51.2)	7.19	(49.7)
Casual	5.09	(40.0)	3.33	(27.2)	5.74	(48.8)	7.29	(50.3)
Total	12.73	12.7	12.26	20.62	11.75	16.75	14.48	22.23
3. Crop Care								
Permanent	19.57	(75.5)	21.55	(85.3)	16.46	(67.9)	16.70	(63.1)
Casual	6.35	(24.5)	3.71	(14.7)	7.78	(32.1)	9.75	(36.9)
Total	25.92	40.2	25.26	42.49	24.24	34.56	26.45	40.60
4. Harvest[3]								
Permanent	1.92	(10.2)	1.87	(13.7)	2.88	(10.3)	1.36	(7.1)
Casual	16.89	(89.8)	11.80	(86.3)	24.96	(89.7)	17.75	(92.9)
Total	18.81	29.2	13.67	23.00	27.84	39.70	19.11	29.34
TOTAL PERMANENT LABOUR	34.34	(53.26)	40.41	(67.97)	30.96	(44.15)	25.25	(38.76)
TOTAL CASUAL LABOUR	30.14	(46.74)	19.04	(32.03)	39.17	(55.85)	39.89	(61.24)
TOTAL LABOUR	64.48	(100.0)	59.45	(100.0)	70.13	(100.0)	65.14	(100.0)

[1] Man days measured in ten-hour days.

[2] Aus, combined traditional and IRRI Aus varieties.

[3] Figures calculated from 1978 Aus harvest, 1979 Aus harvest disrupted due to drought.

Source: Weekly Survey.

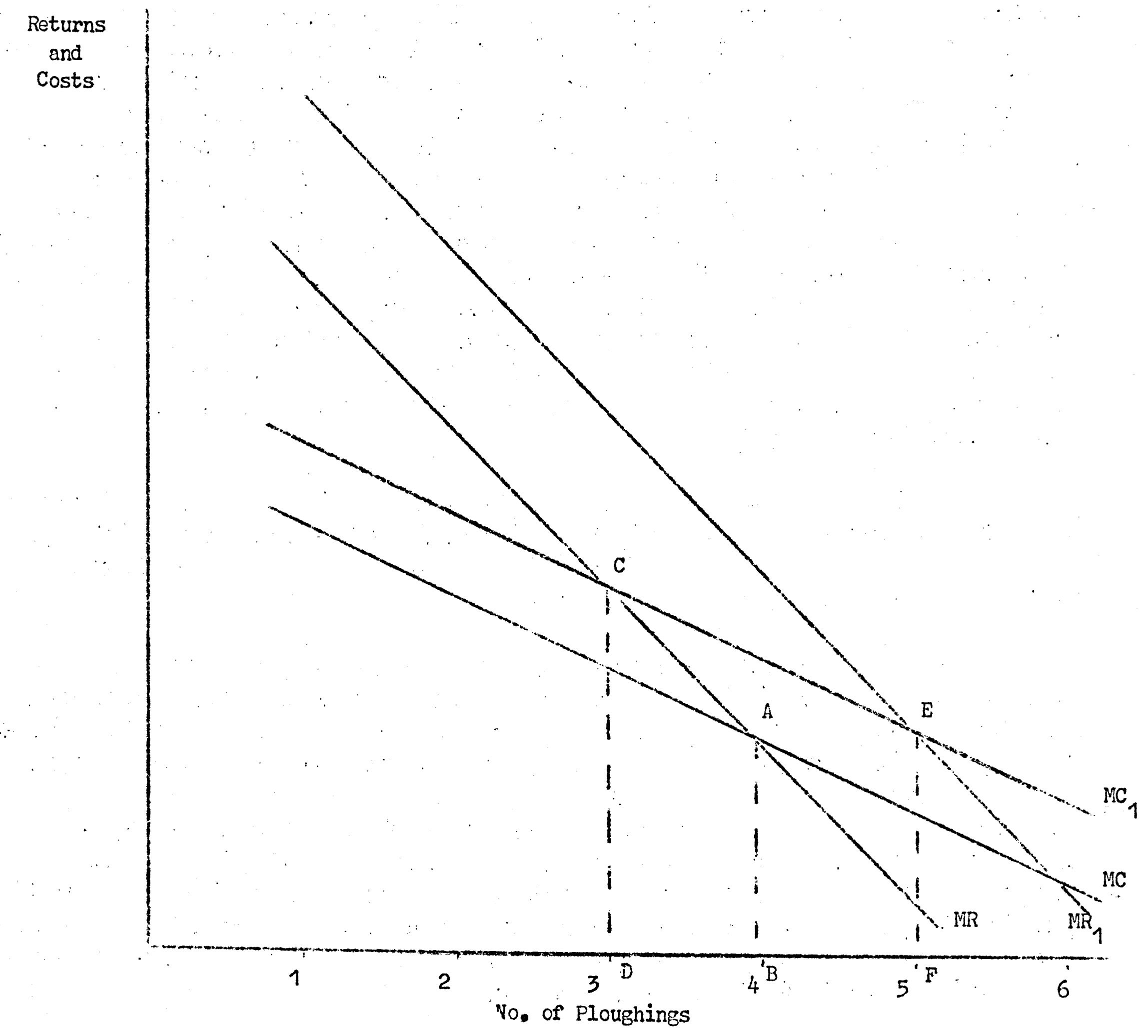
of animal purchase, the condition, age, and sex of the animal and the cost of fodder. A special factor affecting cattle availability in the survey area, beside cyclones, is endemic cattle disease. During the 1978 aman land preparation an outbreak of foot and mouth disease sent hire charges spiralling. The demand for cattle hiring within a particular season varies as the optimal conditions for seed germination or transplanting alter. As can be seen from Table 3.5, the average cost of cultivating an acre during the 1978 aman season was clearly higher for small cultivators (Tk.206/- per acre) compared to the larger cultivators (Tk.81/- per acre). However this figure reflects that small cultivators hire-in more frequently than larger cultivators. The final column of Table 3.5 shows the price paid per day, as can be seen: cultivators with an effective landholding of under two acres paid a mean charge per day for bullocks of Tk.23/-; cultivators with an effective landholding of more than two but less than four acres paid a mean charge of Tk.20/-; while those with an effective landholding of more than four acres paid a mean charge per day of Tk.16/-. Unfortunately, the cell sizes are too small to measure statistical significance, however, larger cultivators have two advantages in buying draught power, compared to smaller cultivators, from which they could benefit. Firstly, by "bulk buying" their draught power: in buying the draught power in larger amounts than small farmers they may be able to acquire it cheaper on a per acre basis. Secondly, draught power by its nature is a 'lumpy' technology: there is a minimum amount of draught power that must be hired in order for any draught power to be hired. If the amount of draught power required is less than this minimum, the excess draught power must still be paid for, thereby increasing the unit cost of draught power for those buying small amounts. The lumpiness of draught power could discriminate against smaller cultivators.[1]

TABLE 3.5: COST OF CULTIVATION FOR CATTLE HIRERS FOR AMAN SEASON

CATEGORY OF CULTIVATOR	AVERAGE COST OF CULTIVATION PER ACRE				AVERAGE NOS. OF DAYS ANIMALS HIRED PER ACRE				Mean Cost of Cultivation per Day
	Mean Cost per Acre	No. of Cases	Standard Error	Standard Deviation	Mean No. of Days	No. of Cases	Standard Error	Standard Deviation	
1. All Cultivators	148.55	31	18.60	103.57	7.0	31	0.99	5.56	21.22
2. Cultivates < 2 Acres	206.43	15	22.90	88.68	8.89	15	1.07	4.15	23.22
3. Cultivates > 2 Acres and ≤ 4 Acres	107.29	8	23.98	67.81	5.37	8	1.32	3.74	20.00
4. Cultivates > 4 Acres	81.28	8	37.67	106.54	5.04	8	2.93	8.30	16.13
5. Sharecroppers	105.04	9	29.99	89.98	4.88	9	1.72	5.16	21.44
6. Cultivator Landlords	157.87	6	39.88	97.68	9.65	6	3.41	8.35	16.36
7. Cultivators	213.92	12	37.23	128.98	8.93	12	1.43	4.96	24.00
8. Landlord Sharecroppers	36.35	4	20.81	26.32	1.92	6	0.56	1.11	18.93
9. Non-Cattle Owners	189.84	23	18.17	87.12	8.90	23	1.09	5.22	21.33
10. Cattle Owners who Hire-in Cattle	29.83	8	7.17	20.28	1.53	8	0.33	0.93	19.50

[1]See Mettrick (1981), Part1 of this Volume.

FIGURE 3.4



The results of the weekly survey suggest that those small cultivators who do not own cattle and who are possibly paying premium prices[1] for their draught power are using more draught power than cattle owners. Is this such a paradoxical conclusion? Assuming draught power to be the only cost of production, consider Figure 3.4: the vertical axis measures returns and costs and the horizontal axis draught power in units of one ploughing. Let the line MC represent the cost of each additional ploughing and MR the marginal return of the extra yield that accrues from each additional ploughing. The optimum number of ploughings is given when the cost of an additional ploughing is equal to the value of the yield that accrues from that additional ploughing. In the case represented by Figure 3.4, it is four ploughings, shown by line AB. The cost of draught power is greater if animals have to be hired. The optimum number of ploughings for cattle hirers is three (where MR intersects MC_1) shown by line CD, while for cattle owners it is four. Yet as has been pointed out this is not the

[1] Due for instance to their greater need to take credit.

situation: cattle hirers are ploughing as often, if not more often, than cattle owners! The major reason for this is that the two categories - cattle owners cultivating larger areas and cattle hirers - value their harvests differently. In a situation where agricultural prices are unstable - the price of the main staple crop, rice, can fluctuate as much as 100% in the course of a season - and where most commodity markets are oligopolistic, dominated by a few merchants, households tend to grow sufficient rice to meet their own needs if they can. This is especially the case with smaller farmers who often pay a lot more than the market price for rice because they frequently have no cash and have to resort to acquiring rice through high interest loans. This leads to a price differential for big and small farmers: the bigger farmers, who easily grow sufficient to feed themselves, sell off their surpluses and value their rice at the price they *sell* to merchants. Smaller farmers, however, who do not cultivate sufficient land to feed themselves value their rice at the price they have to *buy* it.

Even if yields were similar as between small and large farmers (and the evidence suggests that yields on small farms are higher), this would imply a move of MR to MR_1. The optimal ploughings for small farmers rises, say, to five (EF).

There is no point in investing in more ploughings to try to increase production because the money invested would buy more rice elsewhere than it would generate in extra production. Cattle owners being generally bigger land owners than cattle hirers have different cost and revenue curves. This is in a sense obvious: small farmers struggling to achieve subsistence will value rice higher than bigger surplus farmers. In order to minimise costs the smaller farmers will maximise their own labour opportunities, but they will also be prepared to buy the other extra resources, including draught power, if needed, to produce yields and cropping intensities greater than that accomplished by big farmers.

3.3: Land Preparation, Rotations and Tenure

As has already been pointed out the major rice crop is *aman*. This is due more to *aman* requiring less investment and involving less risk, rather than because its yield is higher than *aus*. It involves less risk because although the timing of the monsoon may fluctuate, the monsoon does arrive: the *aus* is not only vulnerable to late rains (as it was in 1979), but also it is short stemmed and so is not usually grown in fields that are flooded to a depth of more than two feet. In addition during May and early June it is necessary to keep the *aus* fields clear of weeds, a task the monsoon performs in the *aman* season by keeping fields flooded.

In the survey area there is no land left deliberately uncultivated for more than a year, although there were reports of *char* lands lying fallow. The *aman* plant is photoperiod sensitive. It's critical period is the latter part of October when it begins to flower: if there is not sufficient moisture, heading will be affected. To prevent this, farmers attempt to ensure *aman* is transplanted by at least late September.

FIGURE 3.5: HISTOGRAM OF FINAL PLOUGHING PRIOR TO AMAN TRANSPLANTING PER PLOT

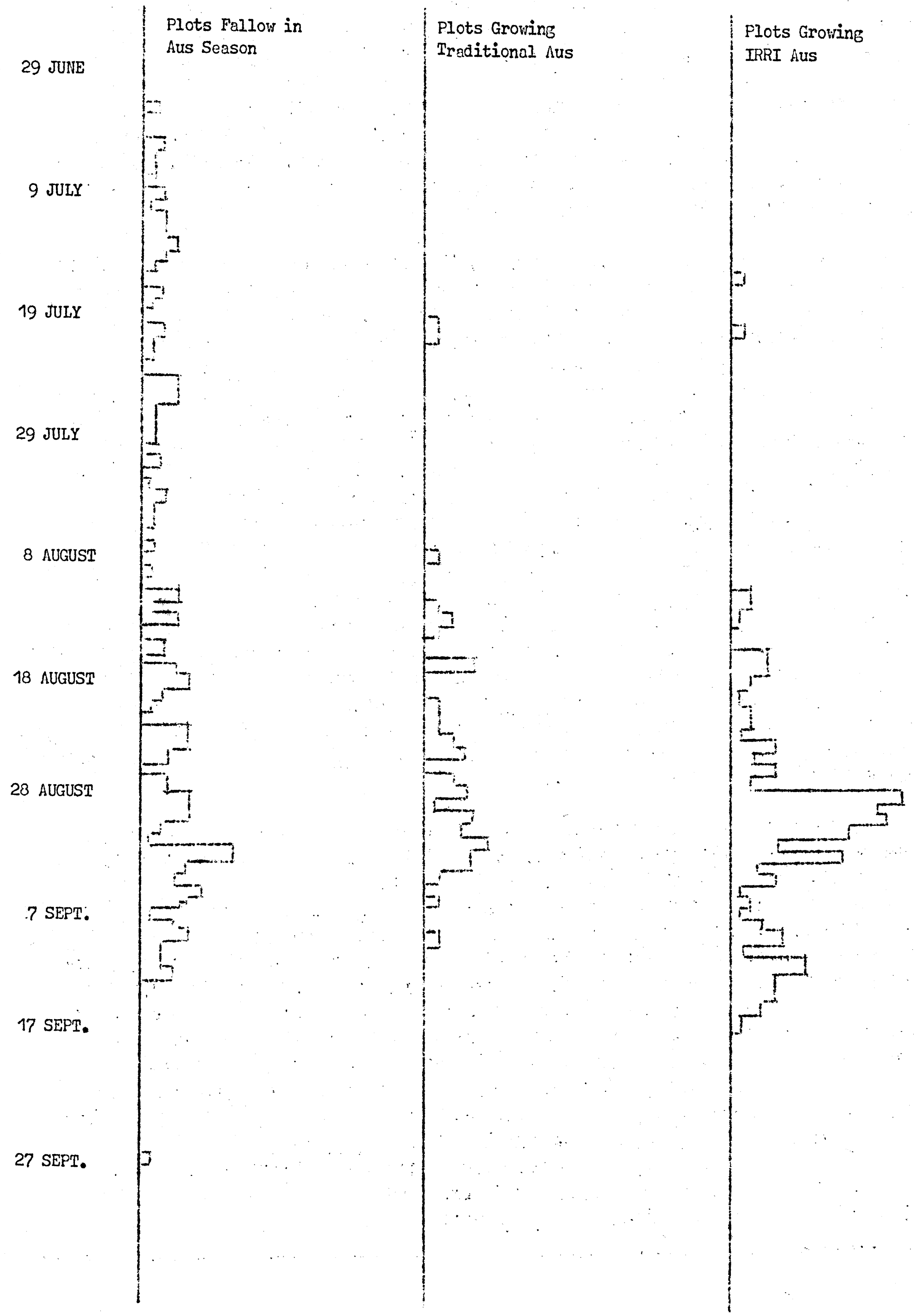


Figure 3.5 is a histogram of final ploughing dates prior to aman transplanting and it clearly shows the abrupt cessation of ploughing by mid-September. All farmers in the weekly survey succeeded in transplanting aman. According to results from the weekly survey, as long as the crop is transplanted by mid-September, there is no correlation between yield and time of transplanting.[1] Given the importance of the aman crop and the critical deadline for its transplanting, there exists for the farmer a definite and definitive land preparation requirement: to get the land prepared for aman cultivation by mid-September. This obvious implication has important ramifications for any analysis of land preparation.

There is no statistically significant difference between the date aman was transplanted in fields that were fallow in the aus season and the date aman was transplanted in fields that had either (a) previously been cultivated with traditional varieties in the aus season, or (b) previously been cultivated with IRRI varieties in the aus season. This is despite the fact that IRRI aus takes some three weeks longer to mature than traditional varieties of aus (and the dates of harvest are significantly different between traditional and IRRI varieties of aus). However, this does not necessarily mean there is no time constraint, only that if there is, farmers would prefer not to grow IRRI rice (or no aus crop at all) than risk the dependable aman crop being late planted. Any draught power constraints would not become apparent through a delay in aman planting; the effects of any such constraints would be, through deliberate farmer decision making, limited to the aus season. In other words, are there cultivators who do not grow an aus crop or choose traditional varieties as opposed to IRRI varieties because they are unsure as to whether they could get the land prepared in time for aman transplanting? This uncertainty on the part of farmers reflects both the cost of ploughing for the aman crop vis-a-vis the return from the aus and aman crops and the degree of security of access to the draught power.

There are two major problems that confound a discussion of the linkage between the complex balancing of labour and draught resources and the decision whether to grow aus, and if so, what variety. One concerns the many factors which determine crop choice and the other concerns the assumptions and the rationale farmers use to relate the different factors. Taking the last point first, it has already been shown how those farmers for whom some resources cost relatively more compared to other farmers, actually use more of those resources than do those farmers to whom they are relatively cheap. It would be incorrect therefore, to assume that because there are cattle owners who do not cultivate aus there is not a draught power constraint on aus. It may be that other farmers are prepared to offer the cattle owner a sufficiently high price during the aus-aman turnaround for him to forego an aus crop and keep his own cultivation requirements to a minimum so as to maximise his hiring of cattle during the land preparation bottleneck for the aman crop.

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[1] $r^2 = 0.00346$.

The cost of land preparation is one of a host of factors and considerations that affect crop rotation decisions. These include:

a) physical factors (land height, soil permeability, flooding regime, soil type, salinity, distance of plot from homestead and plotsize);
b) tenurial factors (land owned or sharecropped);
c) the relationship between relative product prices and relative factor prices (especially in terms of the cost of land preparation); and
d) personal preferences of households and household size.

These factors must be controlled for, if any analysis regarding possible draught power constraints is to be made. Three major physical factors were isolated that farmers claimed affected the choice of cropping rotation: land height, flooding regime and soil permeability. Soil type and the degree of soil salinity in the rabi season were regarded as homogenous throughout the survey area. Appendix A discusses in detail how these physical factors were synthesised into common land-types. Table 3.6 presents the three most common land types that were found in the survey area: higher land, lower land and char land. Higher land refers to medium land, that is free of flooding by the end of Kartik (mid-November) and whose soil is moderately permeable or impermeable. Lower land is medium land not free of flooding by the end of Kartik and all low land. The other major physical feature that can be important in determining rotations is the distance from the farm or homestead to the fields. The further the field is from the homestead the more expensive it is to cultivate. All char land is at least two miles from the homestead, and can be as much as ten miles. Table 3.6 differentiates the main rotations by land type and distance from homestead. The cropping intensity of higher land is 200; for higher land up to half a mile from the homestead the intensity is 204; while for higher land more than half a mile from the household the intensity is 189. For lower land the overall cropping intensity is 171; for lower within half a mile of the homestead the intensity is 172; while for lower land more than half a mile from the homestead the intensity is 163. The cropping intensity of char land is 134. It is especially noticeable that the incidence of IRRI rice declines dramatically on lower land.

The next set of factors to affect cropping rotations are tenure. Appendix B, Tables 3, 4 and 5 show in detail the cropping patterns and intensities by tenure and effective landholding size. There are two major basic forms of land tenure in the survey area: ownership and sharecropping. Table 3.7 shows the effects of tenure on the main cropping rotations as well as the detailed differences arising from land type and distance from homestead. The cropping intensity of owned land was 188, while for sharecropped land it was 175. The most important difference concerns how the land is double-cropped. Whereas 56.32% (Cols.(4)&(5)) and 19.08% (Cols.(6)&(7)) of owned land is cultivated with aus-aman and aman-rabi, the corresponding percentages for sharecropped land is 38.96% and 20.52% respectively. Rabi crops do not seem to be affected by tenure, while aus,(and especially IRRI aus) is.

In Chapter 2 three major types of cultivator were defined: owner cultivator, landlord cultivator and sharecropper. It was shown how these may be further sub-divided by the size of their effective landholding. Appendix B, Tables 6, 7 and 8, present these three major

TABLE 3.6: DISTRIBUTION OF MAIN ROTATIONS BY PHYSICAL TYPE AND DISTANCE FROM HOMESTEAD

	TOTAL Area Acres	Cropping Intensity	AMAN Area %	T.AUS & AMAN Area %	IRRI AUS & AMAN Area %	AMAN & PULSES Area %	AMAN & CASH CROP Area %	AUS, AMAN & RABI Area %
Higher land, less than ½ mile from homestead	334.90	204	5.2	31.8	34.6	4.9	14.2	9.2
Higher land, more than ½ mile from homestead	110.87	189	17.2	21.2	33.2	5.0	16.7	6.8
Lower land, less than ½ mile from homestead	70.44	172	30.8	21.3	15.4	9.1	19.9	3.5
Lowland, more than ½ mile from homestead	15.46	163	40.2	6.2	2.6	31.6	16.6	2.8
Char land	141.48	134	69.4	7.5	6.9	3.9	10.6	2.0
TOTAL	673.15	182	24.2	23.3	25.8	5.7	14.5	6.6

Source: Sociological Survey

TABLE 3.7: DISTRIBUTION OF MAIN ROTATIONS BY PHYSICAL LAND TYPE, DISTANCE AND LAND TENURE

	TOTAL Area Acres	Cropping Intensity	AMAN Area %	T. AUS & AMAN Area %	IRRI AUS & AMAN Area %	AMAN & PULSES Area %	AMAN & CASH CROP Area %	AUS, AMAN & RABI Area %
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ALL OWNED LAND	417.30	188	18.46	26.30	30.02	5.54	13.54	6.14
ALL SHARECROPPED LAND	240.39	175	33.00	19.08	19.88	4.44	16.08	7.52
Owned Higher Land less than ½ mile from homestead	223.34	202	5.7	32.6	35.5	5.5	13.2	7.5
Sharecropped higher land less than ½ mile from homestead	111.56	208	4.3	30.3	33.0	3.5	16.2	12.7
Owned higher land more land ½ mile from homestead	76.79	200	7.9	24.1	34.9	6.3	19.0	8.0
Sharecropped higher land more than ½ mile from homestead	34.08	175	38.1	14.7	29.3	2.0	11.4	4.5
Owned lower land less than ½ mile from homestead	55.27	177	27.7	24.6	19.6	10.2	13.4	4.5
Sharecropped lower land less than ½ mile from homestead	15.17	158	42.3	9.1		5.3	43.4	
Owned Char land	61.90	131	69.5	7.8	13.7	0.42	7.9	0.58
Sharecropped Char land	79.58	134	69.2	7.2	1.3	6.6	12.6	3.0

Source: Sociological Survey.

land type categories. Access to cattle, in particular cattle ownership, does not appear to have a significant, positive impact on cropping intensity.

3.4: Cultivation Charges and Their Relation to Costs

The charge for hiring a pair of draught animals varies. The mean charge per acre for cultivating in the *aman* season was Taka 165/-, and during the *aus* Taka 320/-. This difference reflects both the fact that land preparation takes longer in the *aus* season (11.3 days per acre) compared to *aman* (7.7 days per acre), and that prices charged per day are higher (Taka 28/- as compared with 21/-).

The cost of providing draught power can be calculated by a variety of methods (see Mettrick, 1981). The animal hire charges given above may give an exaggerated impression of the opportunity cost of providing animal draught power.

The charges for hiring a tractor were respectively Taka 50/- for disc-harrowing and Taka 60/- for rotavating.

The cost of providing these services was however very much higher. Based on the calculations set out in Appendix C, they probably average about Taka 550/- per acre. Much of the fixed cost of tractor provision had been met through aid given to promote cultivation after the cyclone. Even so, hire charges only met 50-60% of running costs and thus were maintained by a major element of subsidy.

CHAPTER 4: ALTERNATIVE WAYS OF ACQUIRING DRAUGHT POWER

The discussion so far has been concerned with the general relationship between draught animals and the socio-economic structure. It has shown how draught power, and in particular, the way draught power is organised, determines in part at least, land tenure patterns, eligibility for becoming a sharecropper, and employment opportunities.

This chapter concentrates on the consequences for the economic and social structure of the institutional rather than the technological aspects of providing draught power. This differentiation of technological and institutional effects must be deduced as it has not been possible to attain rigorous enough conditions for institutional research.

Three major means of providing lumpy technology are then compared; namely: private hire, co-operative hire and public hire. It also discusses some of the limitations of institutions in channelling change in the society and economy.

4.1: Technological and Institutional Effects

Institutions may be defined as referring to the rules, regulations, roles and norms that govern access to technology and resources. Draught power institutions are concerned with the ownership and distribution of draught power within a society or community. These institutions govern the relationship between organisations, groups and individuals. Draught power technologies are lumpy technologies; by their very nature they require a certain amount of resources, especially land, to be operated profitably. Tractors, of the kind discussed in this Study, even allowing for double cropping, need 30 to 40 acres a year if both running and capital costs are to be met; draught animals require a minimum of some three and a half acres. In a community where average farm sizes are a little over two acres, access to any lumpy technology is, for many, not going to be through private ownership. Reliance on draught animals may make the economy self-sufficient but this does not mean self-sufficiency for all farmers. It is important that institutions are developed to ensure equal access to technology.

The institution that provides access to draught power can create effects in its own right as well as mitigating and exacerbating the technological consequences of draught power. For example, a common criticism of increasing mechanical power - whether individually owned or hired - is that this increases the size of landholdings.[1] Given the regularity with which increased landholdings have been empirically shown to accompany the introduction of mechanical power there can be little doubt as to their association. However, are such land transfers necessarily due to mechanisation? Similar effects are observable with the ownership and private hire of animal draught power. This suggests that land accumulation is perhaps a product of individual ownership and the private hiring of the means of land preparation - whatever the means may be - animal or mechanical power. Machines,

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[1] See McInerney (1975).

being larger units of draught power, tend perhaps to concentrate the effects of ownership and private hiring and thereby make such effects more discernible, so that increases in land sizes become attributed to increases in mechanisation. The gradual accumulation of land by forty or so cattle owners in a village as a result of hiring their animals out is not as dramatic as the increase in the landsize of one or two farmers who recently have acquired a tractor and hire it out. Tractorisation in this instance merely increases the magnitude of a social process that is already taking place. Tractors may increase the amount of land being appropriated, although there is no a priori reason for assuming so. What tractorisation will tend to do, however, is to decrease the number of those who have the capacity to accumulate land as a result of owning and hiring out draught power.

Thus, tractors may exacerbate or merely highlight trends and social processes that are already in existence. This gives rise to the danger of misattributing some social and economic consequences to technology rather than the institution. The most important positive implication is that an alternative strategy is available: changing the institution rather than the technology - or changing both the institution and technology. If the institutional means of providing access is in a form other than private ownership and private hire, then draught animals or tractors may not lead to increasing landsizes. Such an analysis has ramifications, not just for tractors and land preparation technologies, but for all lumpy pieces of technology, e.g. irrigation.

4.2: Ownership vis-a-vis Hiring

For individual cultivators there will be differences in their decision-making concerning agricultural production, depending on whether they own or hire draught power. In terms, however, of the social and economic structure as a whole, private ownership and private hire are different sides of the same coin. Given the number of farmers owning and cultivating small areas and the lumpy nature of draught power technologies, whatever the technology, some if not most, of the farmers will have to hire. In societal terms it is not possible to speak of the impact of a private ownership as opposed to a private hire system. However, the structural impact will vary depending on the degree of ownership (as say, measured by the percentage of farmers owning draught animals).

In terms of the individual farmer, presumably the ownership of draught power allows for greater control and flexibility of use compared to the hiring of draught power. Yet it has been shown that yields and cropping intensities tend to be greater among those who hire in draught power, and that this state of affairs is due more to differences in goals and opportunity costs between farmers rather than due to any institutional effect. Hiring, as opposed to owning, does not lead to any noticeable differences in production providing hirers, while paying more for their draught power, are still prepared to use it at least as frequently as owners. Such motivation on the part of hirers stems from their poverty rather than because they do not own the means of land preparation. Given such a situation with the differences in motivation between hirers and owners of draught animals, comparison of owners and hirers is of limited value. As far as hirers are concerned a system of hiring that allows the cheapest, easiest and most equitable access to land preparation technologies is the most efficient.

With respect of employment, the hiring of draught power usually means the loss of choice as to whether to hire labour as well as to operate the draught power: labour very often comes as part and parcel of the draught power. Those who own draught power in many cases use their own labour to plough, while those who hire-in draught animals have little or no choice but to employ labour.

With regard to the wider socio-economic effects: the rate of land transfer is in part determined by the percentage of people hiring and owning draught power. The degree of ownership determines the number of potential land accumulators, and the degree of draught power hiring indicates the number of those in jeopardy of losing land.

4.3: The Merits of Various Hiring Systems

As has already been stated those cultivators whose draught power supply problems are most acute - those unable to own draught animals - make up nearly half the population of cultivators. Their most pressing problem is one of access to any means of land preparation. If mechanisation increases, the amount of land required to sustain the technology will also increase; the need for institutions ensuring cheap, easy and equal access will grow accordingly. The issue in Bangladesh concerning the provision of any land preparation technology is not ownership vis-a-vis hiring, but what is the most efficient method of hiring with the least undesirable consequences.

a) Private Hiring.

The system of privately hiring animals was described in great detail in Chapter 2. The fact that non-owners of cattle use more draught power per acre than cattle owners suggests that, besides the fact that non-owners are willing to pay more for their draught power, private hiring does not constrain the availability of draught animal supply - a condition not necessarily met by co-operative or public hiring. In a situation when timeliness of cultivation is crucial, private hiring, by allowing the most flexible access to draught power, is perhaps the most efficient form of hiring in terms of allocation of resources.

The major drawback of private hiring is that it tends to encourage the accumulation of land in the hands of those who hire-out, an effect magnified with the introduction of tractors. Co-operative and public hiring systems can avoid this consequence. The importance of share-cropped land to a category of cattle owners who also hire cattle out has been made clear. As a result of the introduction of alternative draught power, opportunities for these cattle owners to hire cattle out diminish. Some farmers may then no longer be able to afford to keep their cattle, because they are dependent on the revenue earned from hiring their animals out to keep and feed them. Loss of revenue will mean loss of animals; loss of animals could mean loss of share-cropped land.

b) Co-operatives

There were no co-operatives distributing draught power in any of the locations of the Survey. However, in the Comilla survey area, the mechanised site had hired tractors on a co-operative basis, prior to independence, in the late sixties. After some initial success the co-operative collapsed. For an account of the early years of the co-operative see "Introduction of Tractors in a Subsistence Farm Economy" (Bard, 1962). There were many reasons for the demise of the co-operative - technical and organisational - but only those due to institutional failures are of concern here.

Co-operatives in the jargon of sociology are very poor at 'institutionalising conflict'. This is because, in the absence of some external coercion, membership is usually voluntary. The cohesion of the co-operative is very much dependent on the strength of commitment of each individual member. This in turn depends on the function of the co-operative and is related to the success it has in achieving that function. If the function generates 'centripetal forces' then the cohesion tends to be strong. For example, in the case of marketing co-operatives strength comes from uniting in order to sell. On the other hand, the problem of equal access to lumpy pieces of technology is liable to create 'centrifugal forces' as pressure mounts over 'who gets what and when'. If timeliness of access is important, co-operatives are very poor distributors of access to technology, since co-operative ownership does not lead to co-operativeness in use. In a situation where the function of a co-operative creates 'centrifugal forces' - as it would in trying to distribute draught power - the ability of a co-operative to allow equal access is of paramount importance. This introduces the second major weakness of a co-operative - its vulnerability to existing power structures. Unless membership is controlled, a co-operative distributing a scarce resource will quickly become dominated by local élites. The present basis of rural pwoer - ownership of land coupled to membership of large lineages - means that power is concentrated into a few groups and within these groups into even fewer hands. Such a situation could quickly mean co-operatives not just becoming dominated, but also being used to further and reinforce present political power patterns. Conflict generated by competition over scarce resources, already apparent in other parts of the community, will spill over into the co-operative and this would imperil equal distribution of the co-operatively owned resource. It is perhaps a little naive to expect a community that is competing over other scarce resources to co-operate suddenly over the distribution of one particular resource.

Nevertheless, distribution of draught animals through co-operatives may be possible on a limited scale, for whereas tractors or power tillers would be seen as important new resources with potential political power, if equitable control of the co-operative could be achieved, co-operatives concerned with draught power would only attract those who own draught power if there were considerable financial savings. It may be possible to create a system for distributing draught power partly through individual ownership and partly through a co-operative (or co-operatives) of those unable to own cattle.

c) Public Hire

Public hiring is currently limited to tractors. It is the major method of tractor distribution in Bangladesh. The image of public hire is, to put it mildly, a little tarnished. The reasons advanced for the gradual collapse of the tractor hire service have ranged from technical to economic and financial to administrative, organisational and institutional. It is important that administrative, organisational and institutional factors are clearly differentiated.

Institutions have already been defined. Organisation refers to the design and structure of the public hire service and administration to actual performance of that design. Administrative criticisms include poor management, inadequate training, lack of supervision and inefficient operation. Examples of organisational failures include the inappropriateness of schemes for mobilising farmers, the lack of farmer participation in the running of the service, the vulnerability of schemes to local political domination and the command structure of the government service. In Bangladesh, faults appeared first at the administrative level, but while there was scope for improvements in management, very efficient administration would not have saved the public tractor hire service from collapse.

There were two major organisational reasons why the scheme failed:

(1) it could not generate sufficient cash - even with a subsidy to cover running costs; and

(2) there was little, if any, farmer participation in the service.

The cash flow problems have been dealt with in detail elsewhere (Llewellyn-Jones, 1979). The major reason for lack of funds was the low price charged for tractor hire. The low price did not just mean a continuing need for subsidies and an opportunity for additional unofficial payments to be demanded, but much more importantly, it meant that the charge did not differentiate between those most in need of draught power - those who do not own draught animals - and those who had recourse to sufficient draught power without the use of tractors. The price charged for tractors, in this situation must not be so low for it to be cheaper for cattle owners to hire tractors and keep their own draught animals idle. The price charged must be at least high enough to dissuade cattle owners from hiring tractors.

Farmer participation was limited to brokers. For public hire services to be successful there is a need for steady, regular and organised pressure from farmers applied to all levels of the bureaucracy, especially (a) the decision-making level, and (b) at the field operations level. Pressure applied during the life of the service in Char Alexander was erratic: and in the form of flying visits from politicians or government officials. Once the dust settled affairs soon returned to normal. Lively local interest is a prerequisite for all public hire services. In common with co-operatives, one of the many problems of achieving participation is that farmers' organisation become dominated by local élites, and as such they do not represent the smaller farmers. The representation of small and marginal farmers requires the building of social organisations that often traditionally have never existed. Yet the creation of such organisations is crucial if public hire services are to operate successfully.

4.4: Tractorisation and Institutional Choice

First, tractorisation reduces the number of farmers who can own their own source of draught power. Co-operative or public hiring can overcome the social consequences of such a shrinkage in numbers of those owning draught power.

Second, tractorisation, in offering an alternative source of draught power, will mean a decrease in the demand for draught animal power. Some farmers are only able to own draught animals because they hire them out. Hence some of those who do not own enough land to sustain the cattle they own may have to sell those animals if opportunities to hire their animals out decline significantly. The introduction of tractors cannot be ignored by all cattle owners. Bigger farmers will be able to continue owning draught animals after the advent of tractors but there will be a category of farmers who will change from being draught power owners to draught power hirers. Bigger farmers will still have a choice of owning or hiring draught power.

Third, there is a very important side effect for some of those who will lose their cattle. Loss of cattle will jeopardise any land they sharecrop. Tractorisation threatens the amount of land available for sharecropping. So sharecroppers will find themselves in a situation whereby the loss of sharecropped land cannot be compensated by hiring-out surplus cattle since these opportunities are themselves declining. The trend will be for only those who own sufficient land to be able to sustain cattle to keep them. There will be a sharp polarisation of cattle owners according to land area owned. The number of 'Land inadequate cattle owners' will shrink, possibly, dramatically.

4.5: The Case for Co-operative or Public Hire

It therefore follows that if mechanisation progressed and the amount of hiring increased, correct institutional selection and design would become increasingly important: not just to ensure the most efficient form of access but also to avoid certain undesirable social and economic consequences. Given the present social structure there is no reason to assume that the cheapest allows the most equitable access. At present many small private suppliers allow equality of access - anyone who wants draught animals and who can afford them, can hire them - although, in terms of the rest of Bangladesh, this price is expensive. But private hiring encourages land to be transferred from hirers to owners - making worse one of the biggest rural problems, that of landlessness. In addition, the continuing reductions in the amount of free grazing will further exacerbate the land transfer effect of private hiring. Co-operatives have institutional weaknesses in providing access to scarce technology in communities already competing over resources. Yet in terms of the provision of draught animal power, co-operatives represent the only serious alternative to private hire for those unable to own animals; public ownership of draught animals would create great organisational and administrative problems.

For bigger pieces of technology, such as tractors and power tillers however, public hire is the only institution capable of providing access without increasing landlessness.

Institutional choice then, by ensuring equal access to resources, can avoid some of the consequences sometimes attributed to mechanisation. These types of institutions urgently need developing. However, not all undesirable social and economic consequences of developed technology 'imported' into a developing country can be institutionally conjured away. The one major effect of tractorisation that cannot be institutionally controlled is the fact that it reduces the amount of sharecropped land available. Ignoring small landholders (those owning less than two acres) the majority of landowners who sharecrop land out also cultivate a portion of their holdings - much of this cultivation being achieved by hired draught power. It is difficult to assess whether the type of draught power available has any effect on the amount of land that landlords decide to cultivate themselves, but what is very clear is the fact that landlords do cultivate some of their own land, and this often with hired draught power. The appearance of a tractor hire service may encourage them to increase the amount of land they cultivate themselves. Such behaviour is well established and as such its extension would require no innovation. The impact of technology on such private decisions is difficult, if not impossible, to control by institutional means. How is a landlord to be prevented from cultivating land he once sharecropped out, except by land reform. No matter how tractors are institutionally organised they cannot be prevented from being a threat to small sharecroppers: a major part of what sharecroppers offer - the ability to plough land - is provided by tractors.

CHAPTER 5: CONCLUSIONS

1. The socio-economic analysis of resources, social structure and institutions revealed a situation in Noakhali which was at the same time both highly complex and, because of physical conditions and recent history, substantially distinctive from other parts of rural Bangladesh.

2. Estates are small but size distribution is more skewed than elsewhere; there is a complex pattern of land hiring-out and -in on a sharecropping basis, which goes some way towards evening out access to land.

3. The number of draught animals available is low compared with most other parts of Bangladesh; their ownership is widely but unequally distributed and, again, the hiring-out and -in of this resource provides an additional complication to the pattern of use; moreover the pattern of draught animal ownership is not closely related to land ownership. The heavy and increasing pressure on animal draught power has unequal effects within the community. There are many who have inadequate land for subsistence and no draught animals but there are also owners of cattle with inadequate land who are also in a precarious position, being dependent on sharecropping the land of others.

4. The labour force comes partly from landless households (30%) but also from owner cultivators, sharecroppers and cultivator landlords. There is a rigid sexual division in the tasks performed.

5. Capital transfer through credit within the community is a major characteristic, which serves to assist personal survival while at the same time it strengthens social inequality and dependency.

6. The pattern of resource control is of course not static. Against a physical environment which causes a changing pattern of land availability there is also a tendency for land to be concentrated into fewer hands; to some extent this appears to be associated with the ownership of cattle, but this obscures the complex cross-currents of change in resource control within the community and the variety of means by which, and reasons why, some families prosper and others decline.

7. The advent of tractors, initially as a rescue operation following the 1970 cyclone has had an uneven impact due to the factional social structure; the ineffectiveness of the service however has been such as to have a negligible effect on socio-economic patterns.

8. Cropping patterns across three possible seasons, are intimately affected by soils and topography and, overall, by the pressure of population for subsistence.

9. In turn, the demands of the cropping pattern influence husbandry methods and attitudes to resource deployment. Small farmers tend to apply more labour and draught power than large farmers even though they may pay more as cattle hirers. This appears to be accounted for by the fact that while larger farmers producing a surplus measure their costs against the sale price of products, small farmers measure theirs against the price they may expect to pay for food purchases if and when their production is deficient.

10. The physical environment is such that the crucial time in the calendar occurs when the monsoon (aman) rice crop is transplanted in early September. This has a profound effect on how farmers with different types of land order their cropping, and on the annual cropping intensity; these vary to some extent according to land tenure status but very little according to cattle ownership.

11. Cultivation charges for draught power illustrate the influence of market effects where draught animals are concerned. Tractor charges however are so highly subsidised and so unevenly available that they have had little lasting influence on farmers' cultivation policy.

12. Draught power in Noakhali is in short supply and adds to the insecurity of what is basically a very poor society in an already unpredictable physical environment. Yet there are no obvious conclusions that can be drawn about the best method of increasing this supply. The alternatives of improved draught animals or supplementation by tractors both have their attractions and their difficulties.

13. On the one hand urgent attention needs to be paid to the supply of draught animal power, but before any action is taken to improve present land preparation, reliable and secure access to draught power for all cultivators must be assured if improvements in land preparation are going to contribute towards a widespread alleviation of poverty. Failure to attain security and equality of access before introducing improvement in livestock and traditional technology will result in (1) cattle ownership further polarising according to area owned and (2) an increase in landlessness.

The average landholding (2.2 acres) is below the minimum acreage required to feed a household and two draught animals (approximately 3.5 acres). Seventy-five per cent of households own less than 3.5 acres. Forty-seven per cent of households do not own cattle. Seventy per cent of cattle owners own less than 3.5 acres. Households that own cattle, especially those that hire-out draught power, are increasing in land area.

The 70% of cattle owning households who do not own enough land to feed both themselves and their cattle are reliant on free grazing, sharecropping in land and hiring-out cattle. The availability of free grazing is rapidly diminishing as is the land for sharecropping; this is undermining the capacity of small landowners to own draught animals.

Improvements in animal nutrition, animal breeding and traditional technology may have the effect of raising the area of land required to support draught animals, unless other technology rises at the same time; thereby increasing the potential number of households owning insufficient land to support draught cattle. An increase in the number of households who are dependent on cattle owners will further increase the ability of cattle owners to acquire more land. Access to draught power could be improved through policies designed to encourage small groups of farmers, who are unable to own cattle individually, to own cattle co-operatively. These small co-operatives could be affiliated to a larger village organisation. Such co-operatives could be used as a basis for organising small landholders. If access to draught power is changed from private hire to such co-operatives, then any benefits from improvements in present land preparation will accrue to big and small farmers alike.

To compensate for reductions in grazing, changes in farm practices are necessary so as to provide fodder crops on a cyclical basis from within farms' own resources.

14. On the other hand, tractorisation will not alone solve the draught power problem. The comparative study of tractor and animal draught power reported by Gill (1981), to which the Noakhali study contributed, shows no benefits accruing to tractor use as compared with animal draught. Moreover many studies in Southern Asia have testified to the dangers of social inequality following upon tractorisation.

But the closure of the tractor hire station will impair the capacity in the Noakhali area to cultivate land quickly following another cyclone or flood. Two measures, among others, could mitigate this consequence:

(1) the increased provision of mounds and other high and safe places for draught animals during the cyclones and floods, including the restoration of mounds that have fallen into disrepair;

(2) in the event of mechanised land preparation being performed elsewhere in Bangladesh, contingency plans ought to exist to move the machinery rapidly to any disaster affected area.

Also tractors, per se, are not responsible for all consequences that accompany their introduction. The means of access - private, co-operative or public hire - not only exacerbate or mitigate the impact of tractors but also they can be responsible for effects in their own right. Co-operative hire may be suitable for small simple pieces of equipment, such as draught animals, but for larger pieces public hire is more likely to provide equal access. The failure of the tractor hire station to provide reliable and equal access to tractors stemmed from organisational faults rather than any inherent contradictions in the public hire service.

Yet there are limits on the ability of institutions to contain the impact of technology. Ensuring equal access will not necessarily prevent other undesirable consequences. The threat tractors pose to sharecroppers stems not from the fact that sharecroppers cannot hire tractors, but because tractors present a new option to landlords: to cultivate more land for themselves instead of sharecropping out.

In sum, the final conclusion of this study would seem to be that if we assume that growth-with-equity is the only overall objective which will save this vulnerable area from dire and increasing poverty, there is no simple farm power solution which, on its own, is going to achieve this. Rather, a combination of policies must be considered which (1) reduces human pressure on natural resources - probably a combination of improvement in agricultural production and food security with the provision of non-agricultural occupations inside or outside the area;

and (2) increases farm power in such a way that it is economic overall and yet does not cause a worsening (indeed hopefully would result in the improving) of the local distribution of income and political power.

It may well be that Noakhali will remain an area of great risk and personal suffering until some plan of international dimensions can be effectively applied to stabilise the natural resources of the Delta as a whole.

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APPENDIX A: NOAKHALI'S CYCLONE HISTORY

DATE	Area Affected	Type of Calamity	Area Affected (Sq.Miles)	Nos. of Human Lives Lost	Nos. of Cattle Lost	Crop Acreage Lost
9/10 Oct. 1960[1]	Chittagong, Chittagong Hill Tracts, Barisal, Noakhali (Ramgati, Hatiya)	Cyclone, 8" rainfall in two days, tidal bore over islands and low land	4,157	8,149	114,769	74,222
9 May, 1961[1]	Bangladesh in general, Noakhali (Ramgati, Char Alexander & Hatiya)	10' tidal bore in off-shore island of Hatiya and in Char Alexander, Ramgati.	9,009	11,468	77,918	243,707
28/29 May, 1963[1]	Chittagong, Comilla, Noakhali	Cyclone, Max. wind 150 mph. Tidal bore in Noakhali	51,000	11,520	26,543	200,000
7 Oct, 1963	Bakerganj, Comilla, Noakhali	Cyclone, inundation of coastal areas by tidal bore	n.a.	n.a.	n.a.	n.a.
11/12 May, 1965[1]	Dacca, Khulna, Faridpur, Mymensingh, Comilla, Chittagong, Noakhali	Cyclone, 100 mph, coastal districts inundated by 12' storm surge	18,142	20,152	137,889	105,816
15 Dec, 1965[1]	S. E. Bangladesh (Incl. Noakhali)	Cyclone, 130 mph and tidal bore (unusual, out of May-Oct. season)	4,227	850	108,763	10,715
1 Oct, 1966[2]	Chittagong, Bakerganj, Khulna, Comilla, Noakhali	Cyclone 55-90 mph, storm surge 16'	920	382	64,480[3]	217,990
3 Apr, 1968[1]	Noakhali	Tornado	10	32	364	n.a.
12 Nov, 1970	Chittagong, Barisal, Patuakhali, Khulna, Noakhali	Cyclone 74-108 mph, core of hurricane 130 miles, tidal wave max. 22'				
	NOAKHALI			37,319	138,000	118,300
	BANGLADESH			255,786	470,000	1,104,600

[1]Refers to whole storm affected region. [2]Only refers to Noakhali storm affected region. [3]Includes sheep and goats.

Source: Khan (Ed.) (1977) and Alim (1974)

APPENDIX B: PHYSICAL FEATURES AND CROPPING DATA OF THE SURVEY AREA

(a) Physical factors.

Three major physical factors were isolated: land height, flooding, and soil permeability. The information concerning these physical factors was collected by ascertaining the farmers' opinions regarding their fields. Although the information was not independently checked, care was taken before the survey to discover the farmers' categorised differences in these physical factors and these local categories were used. During the following discussion, homesteads, gardens and permanent crop cultivations are ignored. The farmers recognised three different land heights:
(1) highland - not normally flooded; (2) medium - flooded to a depth of one foot in wet season; (3) low - flooded to a depth of more than one foot in wet season. Medium land accounted for 87% of all land cultivated (see Table B.1). Farmers differentiated between fields that were (i) normally drained: free of floodwater by the end of Kartik (mid-November); and (ii) late drained: not cleared of floodwater by the end of Kartik. By implication this late drained land is also vulnerable to flooding early in the monsoon. Some 84% of the land was normally drained (see Table B.1). Farmers distinguish three types of soil permeability: (1) permeable - water percolated through in a few hours; (2) moderately permeable - water stands for up to two days; and (3) impermeable - water stands for more than two days. Over 80% of the cultivated area had moderately permeable soil (see Table B.1). Moderately permeable soil was an asset much valued by farmers and for which they worked hard to achieve through appropriate land preparation. By amalgamating these three physical attributes: five categories of land emerge, to which a sixth, char land, can be added. These six categories are presented in Table B.2. Before discussing actual cropping rotations, it is necessary to outline briefly the 'ideal models' of cropping rotations farmers are aiming to grow.

On high land and medium land free of flooding early two to three crops are possible, the ideal rotations being either (1) T.aman-aus-pulses, or (2) T.aman-aus. This land is most suitable for IRRI aus as the risk of flooding is minimised. On low land and medium land not free of flooding until later, one or two crops are the norm, the usual rotations being either: (1) T.aman or (2) T.aman-traditional aus; or (3) T. aman-rabi, especially pulses. These ideal rotations are in broad agreement with current practices (see Table B.2), although it has to be borne in mind that, all things being equal, there are two important differences between the ideal rotation and the actual cropping pattern. (1) There is a time lag between the ideal and actual practices: the ideal is based on the slow evolution of the present system of agricultural production, while the actual is a response to rapidly changing circumstances. (2) The difference between the ideal and the actual is in part an expression of how the element of risk is differently perceived in the ideal and real situations: physical factors do not lay down absolute conditions, IRRI aus can be grown on fields subject to early or late flooding, but the risk of crop damage is greater than on fields not subject to such flooding.

(b) Tenure

Section 2.1 recognised five types of landholder:
(1) owner cultivators; (2) cultivator landlords; (3) sharecroppers; (4) landlords; and (5) sharecropper landlords. Landlords do not cultivate land and so are of no interest here. Sharecropper landlords in constituting only 4% of all landlords are also ignored.

The cropping intensity of owner cultivators is 182; for cultivator landlords it is 196; and for sharecroppers overall it is 180 (184 on their own land, and 178 on land sharecropped in).

TABLE B.1: DISTRIBUTION OF PLOTS AND PLOT AREA BY SELECTED PHYSICAL FACTORS AND CROPPING INTENSITIES

	PLOTS		AREA		1 Crop[1]	2 Crop[1]	3 Crop[1]	Cropping
	No. of Plots	%	(Acres	%	Area %	Area %	Area %	Intensity
1. Land Height								
Highland - not normally flooded	589	23.0	37.34	5.2	12.23	23.83	1.28	171
					(32.8)	(63.8)	(3.4)	
Medium - flooded to depth of one foot in wet season	1743	67.9	504.37	70.3	53.11	409.86	41.40	198
					(10.5)	(18.26)	(8.2)	
Low - flooded to depth of more than one foot	91	3.6	34.50	4.8	11.34	23.16	-	167
					(32.9)	(67.1)		
Charland	143	5.6	141.48	19.7	98.15	40.57	2.76	133
					(69.4)	(28.7)	(1.9)	
TOTAL	2566		717.69		174.83	497.42	45.44	182
					(24.4)	(69.3)	(6.3)	
2. Flooding								
Normal drainage - cleared of flood water by mid-November	2164	89.3	482.75	83.7	47.56	398.95	36.24	198
					(9.9)	(82.6)	(7.5)	
Late drainage - not cleared of flood water by mid-November	259	10.7	93.46	16.3	29.12	57.90	6.44	176
					(31.2)	(41.9)	(6.9)	
TOTAL	2423		576.21[2]		76.68	456.85	42.68	194
					(13.3)	(79.3)	(7.4)	
3. Permeability								
Permeable - water runs thru' soil in few hours	445	18.4	26.70	4.6	4.17	21.03	1.50	190
					(15.6)	(78.8)	(5.6)	
Moderately permeable - water stands for up to two days	380	15.7	84.84	14.7	7.11	72.51	5.22	198
					(8.4)	(85.5)	(6.1)	
Impermeable - water stands more than two days	1598	65.9	464.67	80.6	65.40	363.31	35.96	194
					(14.1)	(78.2)	(7.7)	
TOTAL	2423		576.21		76.68	456.85	42.68	194
					(13.3)	(79.3)	(7.4)	

[1]Measured acres. [2]Char land not included.

Source: Sociological Survey

TABLE B.2: DISTRIBUTION OF MAIN ROTATIONS BY MAJOR PHYSICAL LAND TYPES[1]

	Aman Area (Acres) %	T.Aus & Aman Area (Acres) %	I.Aus & Aman Area (Acres) %	Aman & Pulses Area (Acres) %	Aman & CashCrop Area (Acres) %	Aman & Rabi Area (Acres) %	Total Area (Acres)	Cropping Rotations
Highland, free of flooding by mid-November permeable	2.73	1.17	4.36	0.54	1.64	0.78	11.22	183
	(24.3)	(10.4)	(38.9)	(4.8)	(14.6)	(7.0)		
Highland, free of flooding by mid-Nov. impermeable	9.50	3.04	7.08	1.88	4.12	0.50	26.12	166
	(36.4)	(11.6)	(27.1)	(7.2)	(15.8)	(1.9)		
Medium land, free of flooding by mid-Nov. mod.permeable	4.66	24.33	33.17	4.20	7.07	7.98	81.41	204
	(5.7)	(29.9)	(40.7)	(5.2)	(8.7)	(9.8)		
Medium land, free of flooding by mid-Nov. impermeable	31.85	105.74	119.55	17.61	59.11	30.50	364.36	200
	(8.7)	(29.0)	(32.8)	(4.8)	(16.2)	(8.4)		
Medium land, not free of flooding by mid-Nov. impermeable	16.60	9.42	8.09	7.04	7.33	2.92	51.40	173
	(32.3)	(18.3)	(15.7)	(13.7)	(14.3)	(5.7)		
Lowland	11.34	6.53	3.13	4.28	9.22		34.50	167
	(32.9)	(18.9)	(9.1)	(12.4)	(26.7)			
Char land	98.15	10.56	9.5	5.54	14.97	2.76	141.48	133
	(69.4)	(7.5)	(6.7)	(3.9)	(10.6)	(2.0)		
TOTAL	174.83	160.79	184.88	41.09	103.46	45.44	710.49	182
	(24.6)	(22.6)	(26.0)	(5.8)	(14.6)	(6.4)		

[1]Components may not add up to totals due to rounding. Source: Sociological Survey.

TABLE B:3: DISTRIBUTION OF OWNER CULTIVATOR BY EFFECTIVE LANDHOLDING AND CROPPING PATTERNS

Effective Landholding (Acres)	Nos. of Farmers	Cropping Intensity	Total Area (Acres)	CROP ROTATION: Aman Area(Acres) (%)[1]	T. Aus & Aman Area(Acres) (%)[1]	I. Aus & Aman Area(Acres) (%)[1]	Aman & Pulses Area(Acres) (%)[1]	Aman & Cash Crop Area(Acres) (%)[1]	Aus, Aman & Rabi Area(Acres) (%)[1]
1. 0.01-2.00	85	195	74.4	5.1 (9.6)	17.2(32.3)	20.6(38.7)	1.1 (2.1)	7.0(13.2)	2.2 (4.1)
2. 2.01-4.00	21	179	56.9	12.9(25.8)	14.5(29.2)	9.1(18.4)	1.8 (3.6)	9.3(18.6)	2.2 (4.4)
3. 4.01 +	10	169	57.7	12.3(31.5)	12.0(30.8)	6.8(17.4)	3.0 (7.8)	4.6(11.9)	0.3 (0.7)
TOTAL	116	182	189.0	30.3(21.3)	43.7(30.8)	36.5(25.7)	5.9 (4.2)	20.9(14.7)	4.7 (3.3)

[1]% of area growing particular rotation

Source: Sociological Survey

TABLE B.4: DISTRIBUTION OF CULTIVATOR LANDLORD BY EFFECTIVE LANDHOLDING AND CROPPING PATTERN

Effective Landholding (Acres)	Nos. of Farmers	Cropping Intensity	Total Area (Acres)	CROP ROTATION: Aman Area(Acres) (%)[1]	T. Aus & Aman Area(Acres) (%)[1]	I. Aus & Aman Area(Acres) (%)[1]	Aman & Pulses Area(Acres) (%)[1]	Aman & Cash Crop Area(Acres) (%)[1]	Aus, Aman & Rabi Area(Acres) (%)[1]
1. 0.01-2.00 Owns < 2.00	17	196	8.8	1.0(18.9)	0.7(13.9)	1.5(28.3)	0.8(15.0)	0.6(10.5)	0.8(13.5)
2. 0.01-2.000 Owns > 2.00	12	206	10.9	0.4 (8.3)	1.8(40.0)	1.9(41.7)		0.1 (1.3)	0.7(15.2)
3. 2.01-4.00 Cult. < 2.00	7	203	9.1	0.4 (6.0)	2.3(33.6)	2.2(33.6)	0.5 (7.5)	0.7 (9.9)	0.6 (9.3)
4. 2.01-4.00 Cult. > 2.00	8	219	22.4	1.3(10.3)	1.4(10.6)	3.1(24.1)	2.4(18.5)	1.0 (7.9)	3.7(28.6)
5. 4.01+ Culti. < 2.00	10	202	13.0		0.2 (1.9)	2.4(27.6)	2.0(23.9)	3.8(47.0)	0.2 (2.3)
6. 4.01+ Culti. > 2.00	13	191	97.4	7.5 (9.8)	19.4(25.2)	31.2(40.7)	4.5 (5.8)	13.8(13.0)	0.4 (0.5)
TOTAL	67	196	161.6	10.6 (6.6)	25.7(15.9)	42.3(26.2)	10.2 (6.3)	20.0(12.4)	6.4 (4.0)

[1]% of area growing particular rotation

Source: Sociological Survey

TABLE B.5: DISTRIBUTION OF SHARECROPPERS BY EFFECTIVE LANDHOLDING BY AREA OWNED, AREA SHARECROPPED BY CROP ROTATION

Effective Landholding (Acres)	Total Owned Area	Area Share-Cropped	AMAN		T.AUS & AMAN		I.AUS & AMAN		AMAN & PULSES		AMAN & CASH CROP		AMAN, AUS RABI		Owned Land Cropping Intensity	Share-cropped Land Cropping Intensity	Overall Cropping Intensity
			Owned Area	Share-cropped Area	Owned Area	Share-cropped Area	Owned Area	Share-cropped Area	Owned Area	Share-cropped Area	Owned Area	Share-cropped Area	Owned Area	Share-cropped Area			
	(Acres)	(Acres)	(Acs)	(Acs)	(Acs)	(Acs)	(Acs)	(Acs)	(Acs)	(Acs)	(Acs)	(Acs)	(Acs)	(Acs)			
1. 0.01-2.00 sharecrops ≤ 100	19.7	16.1	3.7 (18.6)[2]	1.6 (10.1)[3]	4.6 (23.3)	5.9 (36.6)	6.8 (34.2)	3.5 (21.5)	1.6 (8.3)		1.8 (9.2)	1.7 (10.6)	1.2 (6.3)	3.4 (21.2)	187	211	198
2. 0.01-2.00 sharecrops > 100	5.4	27.5		0.9 (3.2)	1.5 (27.3)	9.0 (32.7)	2.7 (50.7)	12.3 (44.8)	0.2 (4.5)	1.9 (7.0)	0.8 (14.5)	3.1 (11.2)	0.2 (3.0)	0.3 (1.2)	204	198	199
3. 2.01-4.00 sharecrops ≤ 100	22.6	6.0	1.4 (6.4)		7.6 (33.7)	1.3 (22.0)	6.7 (29.4)	2.8 (46.0)	0.5 (2.0)	0.2 (4.0)	3.9 (17.4)	1.2 (19.3)	2.5 (11.1)	0.5 (8.7)	205	208	206
4. 2.01-4.00 sharecrops > 100	22.1	53.3	4.8 (21.9)	8.5 (16.0)	3.1 (14.0)	11.9 (21.9)	9.1 (41.2)	17.0 (31.9)	0.8 (3.4)	2.3 (4.3)	2.4 (10.9)	7.9 (14.8)	1.9 (8.6)	5.9 (11.1)	187	195	193
5. 4.01+ sharecrops ≤ 100	12.9	2.9	4.0 (31.0)		2.6 (20.4)	1.4 (50.7)	1.6 (5.0)	0.7 (20.2)	0.8 (5.9)		3.7 (28.8)	0.8 (28.9)	0.2 (1.2)		169	200	175
6. 4.01+ sharecrops > 100	84.7	111.2	27.7 (32.7)	55.8 (50.3)	13.6 (16.1)	11.4 (10.1)	19.1 (22.6)	7.7 (6.9)	5.7 (6.7)	7.0 (6.7)	9.4 (11.1)	21.5 (19.4)	9.2 (10.9)	7.8 (7.0)	178	157	166
TOTAL	167.4	217.0	41.6 (24.9)	66.8	33.0 (19.7)	40.7	46.0 (27.5)	44.0	9.6 (5.7)	11.4	22.0 (13.1)	36.2	15.2 (9.1)	17.9	184	178	180

[2]Relative frequency of rotation for area owned

[3]Relative frequency of rotation for area sharecropped.

TABLE B.6: DISTRIBUTION OF CROPPING INTENSITIES FOR HIGHLAND LESS THAN HALF A MILE FROM HOMESTEAD BY TYPE OF CULTIVATOR AND ACCESS TO CATTLE

	OWNS NO ANIMALS HIRE IN		CATTLE OWNERS HIRE IN				HIRE OUT		TOTAL	
	Crop. Int.[1]	Acres	Crop. Int.[1]	Acres	Crop. Int.[1]	Acres	Crop. Int.[1]	Acres	Crop. Int.[1]	Acres
OWNER CULTIVATOR										
1. Owns ≤ 2.00 acres	205	26.07	199	4.18	194	3.17	203	2.63	203	36.05
2. Owns > 2.01 & ≤4.00 acres	200	6.94	200	0.08	217	11.07	185	5.35	205	23.44
3. Owns > 4.01 acres			201	8.41	141	1.32	187	7.26	190	16.99
OWNER CULTIVATOR TOTAL	204	33.01	200	12.67	206	15.56	189	15.24	201	76.48
LANDLORD CULTIVATOR										
4. EFF Land[2] 0.01-2.00 owns ≤ 2.00 acres	223	2.47	186	1.00	-	-	-	-	212	3.47
5. EFF Land 0.01-2.00 owns > 2.00 acres	188	3.34	158	0.48	-	-	-	-	184	3.82
6. EFF Land 2.01-4.00 culti. ≤ 2.00 acres	214	2.74	200	0.92	300	0.22	-	-	216	3.88
7. EFF Land 2.01-4.00 culti. > 2.00 acres	200	0.46	189	1.50	213	2.24	-	-	203	4.20
8. EFF Land 4.01+ culti. ≤ 2.00 acres	209	2.24	200	1.34	200	0.64	-	-	205	4.22
9. EFF Land 4.01+ culti. > 2.00 acres	200	10.07	196	6.50	192	12.12	200	0.34	196	19.03
LANDLORD CULTIVATOR TOTAL	204	21.32	194	11.74	197	15.22	200	0.34	199	48.62
SHARECROPPER										
10. EFF Land 0.01-2.00 sharecrops ≤ 1 acre	200	4.19	189	2.90	200	3.12	198	3.10	197	13.31
11. EFF Land 0.01-2.00 sharecrops > 1 acre	216	0.74	200	1.52	200	0.37			205	2.63
12. EFF Land 2.01-4.00 sharecrops ≤ 1 acre	283	4.76	208	3.12	187	1.24	200	1.72	237	10.84
13. EFF Land 2.01-4.00 sharecrops > 1 acre	239	0.82	200	0.98	211	3.30	202	2.60	206	7.70
14. EFF Land 4.01+ sharecrops ≤ 1 acre	-	-	200	3.76	225	2.24	192	6.63	200	12.63
15. EFF Land 4.01+ sharecrops > 1 acre	141	3.41	210	3.51	208	10.91	221	4.72	201	22.55
SHARECROPPER TOTAL	216	13.92	202	15.79	208	21.18	202	18.77	206	68.86
TOTAL	206	68.25	199	40.20	204	51.96	195	34.35	202	194.76

[1] Crop. int. = cropping tensity

[2] EFF Land = effective landholding measured in acres

Source: Sociological Survey

TABLE B.7: DISTRIBUTION OF CROPPING INTENSITIES FOR HIGHLAND MORE THAN A HALF MILE FROM HOMESTEAD BY TENURE, LAND SIZE AND ACCESS TO CATTLE.

	OWNS NO ANIMALS HIRE IN		CATTLE OWNERS						TOTAL	
			HIRE IN		(neither)		HIRE OUT			
	Crop. Int.[1]	Acres	Crop. Int.[1]	Acres	Crop. Int.[1]	Acres	Crop. Int.[1]	Acres	Crop. Int.[1]	Acres
OWNER CULTIVATOR										
1. Owns ≤2.00 acres	186	2.96	214	2.53	230	1.10	200	0.50	204	7.09
2. Owns > 2.00 and ≤ 4.00 acres	147	2.61	300	2.50	180	4.70	-	-	203	9.18
3. Owns > 4.01+ acres	-	-	200	6.76	-	-	200	1.36	200	8.12
OWNER CULTIVATOR TOTAL	168	5.57	224	11.79	191	5.17	200	1.86	202	24.39
LANDLORD CULTIVATOR										
4. EFF Land[2] 0.01-2.00 owns ≤ 2.00 acres	-	-	-	-	-	-	-	-	-	-
5. EFF Land 0.01-2.00 owns > 2.00 acres	-	-	-	-	-	-	-	-	-	-
6. EFF Land 2.01-4.00 culti. ≤ 2.00 acres	200	1.56	200	0.16	-	-	-	-	200	1.72
7. EFF Land 2.01-4.00 culti. > 2.00 acres	300	1.90	100	0.23	100	0.04	-	-	275	2.17
8. EFF Land 4.01+ culti. ≤2.00 acres	200	0.79	-	-	-	-	-	-	200	0.79
9. EFF Land 4.01+ culti. > 2.00 acres	210	4.10	200	3.60	200	24.20	200	1.14	201	33.04
LANDLORD CULTIVATOR TOTAL	228	8.35	194	3.99	200	24.24	200	1.14	205	37.72
SHARECROPPER										
10. EFF Land 0.01-2.00 sharecrops ≤ 1 acre	200	0.40	100	0.95	138	0.84	200	0.52	146	2.71
11. EFF LAND 0.01-2.00 sharecrops > 1 acre	-	-	-	-	-	-	200	0.26	200	0.26
12. EFF Land 2.01-4.00 sharecrops ≤ 1 acre	143	1.12	200	2.00	-	-	200	0.32	181	3.44
13. EFF Land 2.01-4.00 sharecrops > 1 acre	-	-	200	0.40	137	1.96	200	0.95	162	3.31
14. EFF Land 4.01+ sharecrops ≤ 1 acre	-	-	200	0.44	200	2.52	-	-	200	2.96
15. EFF Land 4.01+ sharecrops > 1 acre	-	-	-	-	276	5.16	200	1.88	256	7.04
SHARECROPPER TOTAL	158	1.52	175	3.79	221	10.48	200	3.93	203	19.72
TOTAL	200	15.44	208	19.75	204	39.89	200	6.93	204	81.83

[1] Crop. Int. = cropping intensity index

[2] EFF Land = effective landholding measured in acres

Source: Sociological Survey

TABLE B.8: DISTRIBUTION OF CROPPING INTENSITIES FOR CHAR LANDS BY TYPE OF CULTIVATOR AND ACCESS TO CATTLE

	OWNS NO ANIMALS HIRE IN		CATTLE OWNERS						TOTAL	
			HIRE IN				HIRE OUT			
	Crop. Int.[1]	Acres	Crop. Int.[1]	Acres	Crop. Int.[1]	Acres	Crop. Int.[1]	Acres	Crop. Int.[1]	Acres
OWNER CULTIVATOR										
1. Owns ≤ 2.00 acres	156	1.36	–	–	–	–	–	–	156	1.36
2. Owns > 2.01 and ≤ 4.00 acres	145	4.44	–	–	–	–	100	2.35	129	6.79
3. Owns > 4.01 acres	–	–	124	3.30	–	–	100	4.58	110	7.88
OWNER CULTIVATOR TOTAL	148	5.80	124	3.30	–	–	100	6.93	122	16.03
LANDLORD CULTIVATOR										
4. EFF Land[2] 0.01-2.00 owns ≤ 2.00 acres	–	–	–	–	–	–	–	–	–	–
5. EFF Land 0.01-2.00 owns > 2.00 acres	–	–	–	–	–	–	–	–	–	–
6. EFF Land 2.01-4.00 culti. ≤ 2.00 acres	–	–	–	–	–	–	–	–	–	–
7. EFF Land 2.01-4.00 culti. > 2.00 acres	–	–	–	–	–	–	–	–	–	–
8. EFF Land 4.01+ culti. ≤ 2.00 acres	100	3.23	–	–	–	–	–	–	100	3.23
9. EFF Land 4.01+ culti. > 2.00 acres	100	3.52	–	–	200	3.10	–	–	147	6.62
LANDLORD CULTIVATOR TOTAL	100	6.75	–	–	200	3.10	–	–	131	9.85
SHARECROPPER										
10. EFF LAND 0.01-2.00 sharecrops ≤ 1 acre	–	–	–	–	–	–	–	–	–	–
11. EFF Land 0.01-2.00 sharecrops > 1 acre	–	–	–	–	–	–	–	–	–	–
12. EFF Land 2.01-4.00 sharecrops ≤ 1 acre	100	0.24	200	2.16	–	–	100	1.60	194	4.00
13. EFF Land 2.01-4.00 sharecrops > 1 acre	–	–	200	0.84	236	1.00	170	0.50	209	2.34
14. EFF Land 4.01+ sharecrops ≤ 1 acre	–	–	–	–	–	–	–	–	–	–
15. EFF Land 4.01+ sharecrops > 1 acre	100	5.25	200	3.20	–	–	113	11.62	124	20.07
SHARECROPPER TOTAL	100	5.49	200	6.20	236	1.00	125	13.72	142	26.41
TOTAL	115	18.04	174	9.50	209	4.10	117	20.65	134	52.29

[1] Crop. Int. = cropping intensity index

[2] EFF Land = effective landholding measured in acres

Source: Sociological Survey

APPENDIX C: COSTS OF TRACTOR PROVISION, NOAKHALI

A rapidly changing price structure is the major problem in trying to calculate the costs of tractorisation: the inflation rate in prices of tractors and spare parts, the regular increases in the price of crude oil and the fluctuations in the rate of exchange between Taka and other foreign currencies, require the arithmetic to be continually re-calculated. In addition, estimates of tractor life, spare part requirement profiles, and even the expected work load of tractors, are not available to any degree of accuracy. The major reason for the lack of accurate information, despite nearly ten years' experience of operating tractors, is not so much because of defective design of record systems as because record systems are not properly kept and because tractors were frequently transferred between hire stations.

The following calculations are based on the assumption of 25 tractors with a life of six years operating for some 400 hours a year (5 hours a day). The rate of exchange is calculated at Taka 33/- to £1. Operating capacity is assumed to be 80%.

Workshop

When completed in 1974 the workshop buildings and machinery cost an estimated £200,000; the cost of the workshop itself is estimated at 60% of that total cost. Allowing for 50% inflation since 1974, the cost of building in 1980 is approximately £180,000. Straight line depreciation of the workshop is Taka 396,000 (£12,000) per year.

Workshop machinery

The workshop machinery needs to be comprehensive: not only is there no supply of electricity available, but also the service must operate in an infrastructural vacuum and must therefore be self-contained. The life of workshop machinery and spare part requirements are difficult to calculate: all the machinery bought in 1974 was still in good working order in 1979, although little had been regularly used. Workshop machinery is estimated to have a life of eight years. The cost of spare parts during the life of the workshop is estimated at 10% of the total cost of machinery. Allowing for 50% inflation since 1974, cost of workshop machinery in 1980 is approximately £120,000. Straight line depreciation of workshop machinery is Taka 495,000 (£15,000) per year and the cost of spare parts is Taka 49,500 (£1,500) per annum.

Interest on workshop and workshop machinery

At a simple interest of 10% per annum, interest on the workshop is Taka 594,000 (£18,000) per year and on the workshop machinery interest is Taka 396,000 (£12,000).

Tractors

Besides the 25 tractors, rotavators and disc harrows or chisel ploughs are required. The total cost per tractor/rotavator/cultivator unit, landed at Chittagong was approximately, in 1980, £7,500). Assuming the Government will not sell tractors to the private sector there is only nominal scrap value, which has been ignored for this calculation. Given a six-year life, straight line depreciation of all tractors and implements is Taka 1,031,250 (£31,500) per annum.

Interest on tractors

At simple interest of 10% per annum, interest on tractors and implements is Taka 618,750 (£18,750) per annum.

Maintenance and repairs

This is the most contentious of all items. Excessive costs of maintenance and repair are due to: (1) ill-trained staff operating badly set equipment, or equipment in need of maintenance or minor repair; (2) poor supervision, especially as a result of dispersal of units; (3) use of equipment in bad conditions; (4) damage to equipment in transport between jobs; and (5) high cost of spare parts, especially due to high cost of despatch to remote units in case of emergency (Llewellyn-Jones, 1979, p.13). Spare part requirements can be divided into (i) expected and (ii) contingency. Expected requirements include consumables such as filters and linings and other parts expected through normal wear and tear to be replaced during normal servicing. These were calculated, as a percentage of the total price for a tractor unit as follows: 0.5%; 2%; 3%; 5%; 1.5% and 2%, for each consecutive year during the six year life span. The contingency cost was estimated at a flat rate of 2% of total value per year. Spare parts approximately cost 26% of the total cost of a tractor over a six-year period. Average cost of spare parts (plus 10% interest to finance) is 4.77% of total cost of tractor unit per year. Cost of spare parts is Taka 289,163/- (£8,763) per annum.

Diesel and Lubricants

Estimated at one gallon an hour at Taka 15/- a gallon, plus a gallon for transport from station to field. Total cost of diesel is Taka 144,000 (£4,364) per annum. Cost of lubricants estimated at 10% of fuel cost. Total cost of diesel and lubricants Taka 158,000 (£4,800) per annum.

Labour

This includes drivers and staff of mechanics, assistants, storemen and others employed at hire station. In the 1978/79 Establishment figures (Llewellyn-Jones, 1979, p.29) the ratio of drivers to station staff (excluding administrative staff) was 1:0.7 . Assuming an average wage of Taka 350/- a month per man, total labour cost is Taka 180,600/-(£5,473) per annum.

Administration

This includes the salaries of Assistant Engineers, Unit Officers, clerks and typists, as well as the overhead cost of offices, telephones, postage, allowances, etc. The ratio of drivers and workshop employees to administrative staff is 1:0.27 according to 1978/79 Establishment figures (Llewellyn-Jones, 1979 p.29). The ratio of overhead costs, allowances, travel allowances, house rent, other allowances, office rent, taxes, transportation charges, telephone, postal and telegram charges, insurance, office repairs, electricity, miscellaneous expenditure, printing and stationery, and furniture to total salaries was 1:1.5 (Llewellyn-Jones, 1979, p.6). Estimating average administrative and management salaries at Taka 500 per month, total salaries for administrative staff are approximately Taka 69,660/- (£2,111) per annum, with additional administrative charges of Taka 104,495 (£3,167) per annum.

The cost of operating 25 tractors per year in Char Alexander is approximately Taka 4.4m/- or £133,000. As can be seen, fixed costs represent 80% of total costs, this reflects the huge expense of operating tractors in an institutional vacuum. Over half the fixed costs are connected with the establishment of workshop and workshop machinery. Surprisingly, diesel and lubricants represent a small percentage (3.6%) of total operating costs. Increases in operation time can quickly cut costs: an extra acre cultivated per day would reduce the hourly cost from Taka 547.85/- to Taka 493.32/-; or an increase in operating capacity from 80% to 90% would reduce operating costs per hour by a similar amount. There is scope for efficient management to reduce the element of capital cost per operated hour. However in terms of agricultural cultivation such scope is limited. The 400 hours a year demand for each tractor is based on two seasons of demand for mechanised land preparation of 30 and 50 days respectively in duration for aman and aus/rabi. As can be seen from histogram Figure 3.5, there is a very limited period for ploughing aman and this cannot realistically be expected to be expanded. Some potential may exist in the aus/rabi season for increasing tractor use, but BADC's present estimate of 80 days work availability per tractor per year is very realistic. Hopes for operating tractors on the other 285 days a year - so reducing the high proportion of capital costs - depend either on tractors moving to other areas during the off-peak demand period (as happened to some extent) or to using tractors for non-agricultural purposes such as haulage.

TABLE C.1: COST ESTIMATE OF OPERATING TRACTOR STATION FOR ONE YEAR

		Takas
Workshop depreciation		396,000
Interest on Workshop		594,000
Workshop machinery		495,000
Maintenance of workshop machinery		49,500
Interest on workshop		396,000
Tractor depreciation		1,031,250
Interest on tractor		618,750
Maintenance on tractor		289,163
Diesel and lubricants		158,400
Labour		180,600
Administration:	Salaries	69,660
	Allowances	104,495
TOTAL COST OF OPERATING STATION FOR ONE YEAR		4,382,818

COST ESTIMATE OF OPERATING A TRACTOR PER ACRE

		Takas	% of Total Cost
Workshop depreciation		49.50	9.0
Interest on workshop		74.25	13.6
Workshop machinery		61.86	11.3
Maintenance of workshop machinery		6.19	1.1
Interest on workshop		49.50	9.0
Tractor depreciation		128.91	23.5
Interest on tractor		77.34	14.1
Maintenance on tractor		36.15	6.6
Diesel and lubricants		19.80	3.6
Labour		22.58	4.2
Administration:	Salaries	8.71	1.6
	Allowances	13.06	2.4
TOTAL COST OF OPERATING A TRACTOR FOR ONE ACRE		547.85	100.0

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