Bangladesh Journal of Agricultural Economics, 3(1), 1980, 1-26

DRAFT POWER SHORTAGE AND MECHNIZATION OF TILLAGE IN BANGLADESH*

M.A. Jabbar**

ABSTRACT

This paper shows, by using census and various survey data, that there is absolute shortage of draft power in the country. Two important manifestations of shortage are : (1) 40-50 per cent of power animals are female and this proportion has been increasing. (2) the quality of animal is poor and this also has been deteriorating. The paper identified two major causes of increased use of female rather than engine power to meet power shortage. First, the characteristics of prevailing agrarian structure with small-scale fragmented farming, unequal ownership and consequent prevalence of sharecropping inhibit rapid adoption and efficient use of improved farm technology. Second, although draft power shortage has been recognized for a long time, no consistent policy has been pursued to solve the problem. Consequently draft power shortage has contributed, along with many other things, to the slow growth of agricultural production and employment. It is concluded that a clearly defined mechanization policy need to be formulated very urgently. The most immediate objective of such a policy should be to find ways of restoring the social position of the cow as the producer of milk.

I. INTRODUCTION

Broadly defined mechanization is a process designed to reduce energy from biological sources (men and/or animals) by using newer and better tools; the level of sophistication and sources of power for the new tools will be governed by the nature of the decision making environment and perceived objectives of the decision making individual and/or the society. The objective may be either to increase output or reduce cost or reduce drudgery of labour or a comibination of them. In a wider perspective, mechanization will manifest itself as a pattern of investment in farm power which is explicable and predictable only within the framework of a social system or in a limited sense, an agricultural system (see Figure 1). The interrelationship among the elements constituting a social/agricultural system is neither unidirectional nor liner so that a certain degree of change at any point, say the level of mechanization, may generate different degrees of change in different directions.

---

* This is a slightly revised version of a paper presented at the "Symposium on the Mechanization of Small-scale Peasant Farming", Hokkaido, Japan, July 7-10, 1980. This paper is based on part of the work of an ongoing project sponsored by the Agricultural Development Council, In; New York.

** Assistant Professor, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensignh.

So viewed, the question is not whether to mechanize farming in Bangladesh, but which operations should be mechanized, what form it should take and what the scale of mechanization should be. However, only tillage is being discussed in this study primarily because it is the most important farm operation for which the need for improving the level of mechanization has long been debated.

More than 99 percent of cultivated land in the country is prepared with bullock drawn country plough. Farms owning tiny plots but not owning power animals sometimes use human labour with a spade for pulverizing soil if they find hiring of animals uneconomic. Less than 1 percent of the land area is cultivated by tractors and power tillers received as grant or imported for experimental purposes on government farms and for distribution to private farms. Farmers have been using local implements for hundreds of years without major change in structure. It appears that there has been little improvement in the level of mechanization in tillage operations.

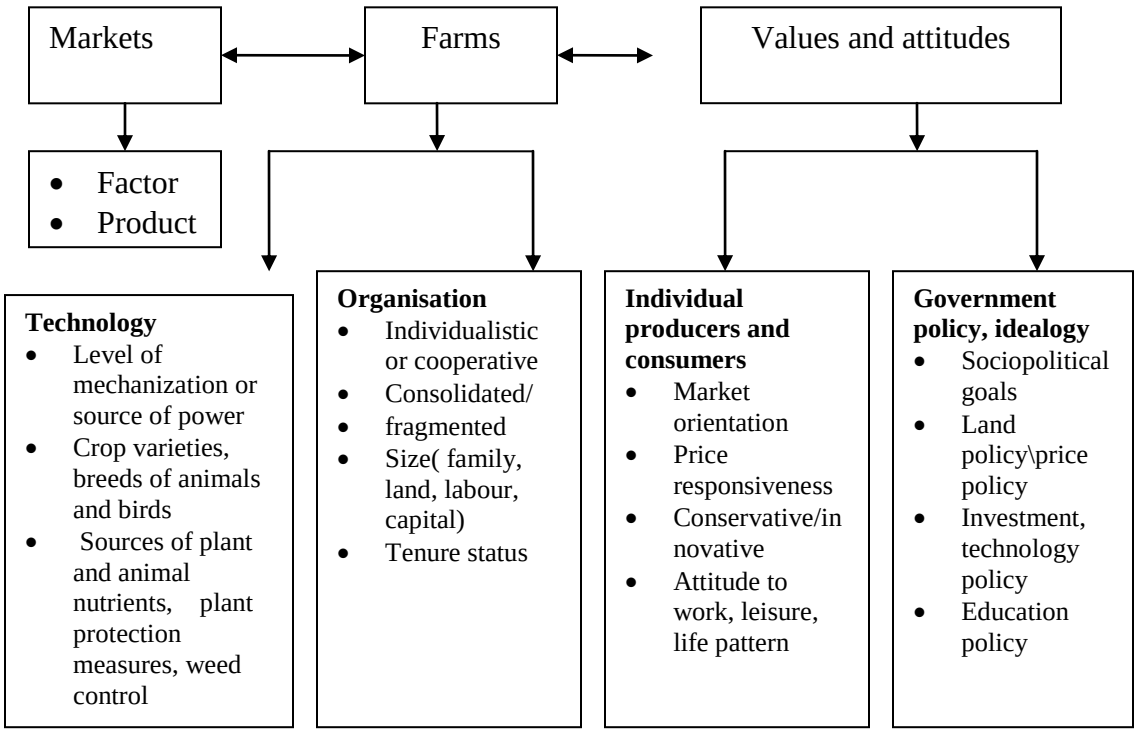
Under the circumstances, by improvement in the level of mechanization is generally meant substitution of engine power (power tiller, tractor) for animal power and human labour. Such substitution may be advocated on the following grounds (see, Binswanger 1978 and Gill 1979-80):

1. Animal power is a primary constraint to agricultural production. Other things remaining the same, engine power can make a net contribution to output and employment through better quality tillage, more precise and timely operation thus helping to raise yields and cropping intensities.
2. Relative prices of animal and engine power may be such that cultivation with engine power may be cheaper, thus more profitable.

When put on a time scale, the two situations described above may become parts of a continuous process of mechanization.

Since bullocks are still the only source of power for tillage in Bangladesh, Section II of this article is devoted to measuring the adequacy of available draft power. The main contention of this section is to test the hypothesis that there is absolute shortage of draft power in the country. In Section III, the causes of non-improvement in the level of mechanization are discussed. In this regard the role of agrarian structure and government policy with respect to mechanization are discussed in detail. In Section IV, the consequences of the current level of mechanization are discussed. Some polity conclusions are drawn in section V.

Figure 1. Elements of an agricultural system



II. ADEQUACY OF DRAFT POWER

Adequacy is the ratio of requirement to availability at a given time for a given technology. So defined, measuring adequacy for the whole country turned out to be difficult primarily because comprehensive and accurate information on both requirement and availability of power was hard to get.

The 1960 census of agriculture had a small section on livestock. The reliability of this census has always been questioned. According to this census, there were 9.89 million work animals on 6.14 million farms (GOP 1961).

The Bangladesh Planning Commission stated in 1973, "Most estimates show that livestock output in Bangladesh has progressively declined since 1964-65" (GOB 1973, p.125). But information on livestock for the 1960s period is scanty and unreliable to verify the above statement. Figures for the seventies show s slowly rising livestock population (Table 1). The actual bases of these figures are not known[1]. The decline of

Table 1: Cattle and Buffalo population in Bangladesh, 1965-1980

Reference year	Total head 000						
	Bullocks	Bulls	Cows	Calves	Total cattle	Buffaloes	Total
1965	-	-	-	-	22989	641	23630
1970	-	-	-	-	25886	835	26721
1970/71	7300	300	4500	5900	18000	3800	21800
1972	8500	a	4400	5000	17900	400	18300
1972/73	7831	388	8396	7815	24430	445	24875
1973/74	7964	399	8539	8057	24959	445	25404
1974/75	8099	410	8684	8307	25470	445	25915
1975/76	8237	423	8832	8556	26057	445	26502
1977a	8474	223	8028	5574	22300	851	23151
1977b	-	-	-	-	20000	469	20469
1979/80	-	-	-	-	-	-	31000

a. included in bullocks - Not available

Source: For 1965, 1970 and 1972/73-1975/76 (GOB 1978)
1970/71 (GOB 1973)
1972 (IBRD 1972)
1977a (FAO 1977)
1977b Agriculture census of 1977 reported through a press release on 18 November 1980.
1979/80 (GOB 1980)

livestock population in 1972 compared to 1970/71 was due to loss of some 2.8 million heads (an unpublished government source say 0.47 million heads) during the cyclone of November 1979 and indiscriminate slaughter of about 2.3 million heads by the Pakistani army during the War of Liberation in 1971 (Odend'hal 1978; Mettrick 1976).

Estimates of the number of work animals are as doubtful as the number of total livestock. IBRD estimated 11.4 million power animals for 1972; Planning Commission estimated around 10 million for 1973; FAO estimated 12.48 million for 1977; and the Planning Commission again estimated 8.2 million for 1977/78 and 10.3 million for 1979/80 (see, IBRD 1972; GOB 1973; FAO 1977; GOB 1978; GOB 1980).

Even if these numbers are considered reliable, were they enough or did they supply enough power for tillage and haulage operations? In Bangladesh, there is about 22.5 million acres of cultivable land. About 11 million power animals therefore mean 0.5 animal for each acre of cultivable land. The Directorate of Livestock Services consider that a pair of bullock is enough for optimum tillage operation of 4 acres of cultivable land irrespective of the intensity of cropping[2] (FAO, 1977). In that sense overall draft power availability for tillage, excluding haulage, appears to have been adequate until now.

However, this conclusion has to be reserved until composition of the power animals, their quality and ownership patterns are considered.

Composition of Power Animals

Nearly twenty nine percent of the power animals used in 1960 were cows (Table 2). Since then, the proportion of cows used as power animal has increased rapidly because of the following reasons:

(a) Before partition in 1947 very few cows were used for ploughing[3]. Replacement cattle then would come from Wast Bengal. After partition this source of supply has largely been lost, cattle are not being legally imported but a small number come through smuggling (Odend'hal 1978).

(b) Growth rate of local livestock population has been slow because of (1) high mortality (FAO estimated 60 percent mortality of calves up to weaning). (2) slaughtering of good quality prime cattle in large number on festive occasions particularly the EID-UL-AZHA, (3) slaughtering of good quality prime cattle in large number on festive occasions particularly the EID-UL-AZHA, (3) slaughtering of cattle for meat[4].

Thus milk cows gradually came to be used for ploughing in the face of draft power shortage. But once a milk giving cow is used for draft purposes, her reproductive capacity (fertility) and milk production potential decreases probably because of physiological changes[5] and too much use for draft may cause complete loss of reproductive capacity. The consequence of using milk cows for draft is therefore, less and less power animals, milk cows, meat, and milk etc. in the future leading to more and more dependence on milk giving cows for draft.

Quality of Power Animals

Quality of animals depend on breed and feed. The local breeds are generally small in size. Livestock is reared and maintained by way of mixed farming. The entire livestock population live exclusively off the byproducts of the crops grown for human consumption, e.g. paddy straw, weeds from crop fields, rice bran, oil cakes, pulse bran etc., so the level of nutrition is generally very poor[6]. Moreover, level of nutrition has gradually deteriorated because of the following reasons:

(a) Previously some seasonal fodder used to be grown on low quality land. With expanding population creating pressure even on low quality land and also with the availability of irrigation for dry season HYV rice/wheat production, the opportunity cost of producing fodder has increased. During 1964/65 to 1977/78, acreage under paddy and wheat has increased at the rate of 0.60. percent per annum while acreage under oil seeds and pulses has decreased by 0.13 percent per annum (Hossain 1980). In 1979/80 wheat season, FAO agronomist in Bangladesh cautioned that too much pulse acreage was being replaced by paddy and wheat (Brammer 1980).

Table 2: Composition of power animals in different years

Year	Location	% of animals in reference year					
			Cows				
		Bullocks	Dry	In milk	All cows	Buffaloes	Total
1960	Bangladesh	67.8	NA	NA	28.8	3.4	100
1967	Mymensingh	56.0	NA	NA	43.0	-	100
1972	Bangladesh	74.5	NA	NA	24.6	0.9	100
1977	Bangladesh	67.9	21.4	5.4	26.8	5.3	100
1978	Mymensingh	46.7	16.9	36.4	55.3	-	100
1979	Mymensingh & Dinajpur	61.0	NA	NA	39.0	-	100
1979	Dacca	20.0	NA	NA	80.0	-	100

NA Not available

Source: For 1960 Census of Agriculture (GOP 1961)
1967 A sample of 40 irrigated winter rice growers (Masud and Underwood 1969).
1972 World Bank Agriculture Sector Study (IBRD 1972)
1977 FAO/Bangladesh Livestock Sector Study (IBRD 1972)
1978 A sample of 50 farms (Ghani 1979)
1979 A sample of 100 Tribal households each in Mymensingh and Dinajpur (Jabbar 1980)
1979 A sample of 60 households (Mack 1980)

(b) Net availability of paddy straw, the main roughage, has also decreased though area under paddy has increased. This is because: (i) Straw output per unit of land is lower for HYVs compared to local varieties. (ii) All HYV acreage do not represent net additional acreage; HYVs grown in the monsoon season (called Aman season) actually replace local varieties. About 15 percent of Aman rice is now HYV, (iii) HYVs growth in dry season are usually harvested when monsoon already sets in (May-June), so in most cases straw get rotten and become unsuitable for animal consumption. (iv) The digestibility of HYV paddy straw is also much lower than local paddy straw[7].

(c) HYVs are generally sprayed with insecticides, as a result weeds from HYV fields become unsuitable as animal feeds.

There is also a seasonal dimension in the availability of feeds and work. The times of hard work do not always coincide with the times of adequate and good quality feed. Thus, animal health once impaired due to hard work and insufficient feed may not

regain full potential again. The animals also suffer from various diseases, the most important growth/health retarding being the presence of internal parasites.

The consequences of poor nutrition and diseases is reflected in decreasing body weight of animals. From intuitive observation Masud and Underwood (1969) assumed body weight of an average size work animal as 500 lbs; Mettrick (1976) assumed 350-450 lbs for bullocks and 300-400 lbs for cows; FAO (1977) assumed 500 lbs for an average animal. Estimated body weight of different categories of animals of two groups

Table 3: Body weight of different types of animals, 1979-80.

Location	Body weight per animals in ibs					
	Young cattle	Milk cow	Milk-cum power cow	Power animals	Bulls	All cattle
Mymensingh	225	351	363	403a	d	315
Dacca	174	345b		466c	392	d

a. Both dry cows and males
b. Includes dry cows used for power
c. Only bullocks
d. Non Not available

Source: Ghani 1979; Mack 1980

of sample farms are given in Table 3. These figure support the low level assumption of Mettrick. Compared to Indian power cattle, or even Wast Bengal cattle, Bangladesh cattle are much weaker (Table 4).

In 1970, a committee on farm mechanization assumed 0.33 HP per head of a West Pakistani work animal (comparable to the size of the animals of Karnal, Punjab) but 0.30 HP, 0.25 HP and 0.5 HP respectively for Bangladeshi bullocks, cows and buffaloes (GOP 1970). Body weight information given earlier suggest that horse power rating of 1970 are not valid anymore. The planning commission assumed 0.25 HP per head of animal in 1978 for the Two year plan (GOB 1978).

Increased use of cows and gradually degrading health condition of animals, therefore, imply that actual horse power availability in the country is much less than the number of animals would suggest.

Table 4: Body weight and draft capacity of selected Indian cattle

Location	Body weight per animal, ibs	Draft per animal, ibs
Bankura, West Bengal	474	73
Patna, Bihar	501	60
Karnal, Punjab	1047	148

Source: BARC 1975

Ownership Pattern of Animals

Most recent national level data on ownership is available from the 1969 Census. Ownership of power animal according to size of holding reveals yet another dimension of draft power shortage. In 1960, sixty five percent of all farms owned power animals but only 41 percent of farms below 2.50 acres owned power animals (Table 5). The remaining farms either hired bullocks from others or used spade for pulverizing soil. Most small farms have so little land that they find maintaining a pair of animal uneconomic. A small proportion of large land holders also do not own any power animal.

The number of animals per farm increases with size of holding but land area per animal increases as well suggesting that the number of animal does not increase as fast as land area. But differences in the availability of actual horse power per unit of land area may be more than differences in the number of animal if the kind of animals used by various sizes of farms and their quality are considered. Table 5 shows that with increase in farm size, the percentage of bullocks and buffaloes increased and that of cows decreased. Information available from a number of sources shown in Table 6 suggest that the aoverage value (reflecting quality and sex composition) of animal per head increases with farm size. Evidence from another source also suggest that smaller farms use more over aged and under aged animals for power than medium and large farms (Ghani 1979).

Even if the sex, age and quality differences of animals in various sizes of farms are adjusted, small farms owning power animals appear to have excess power and large farms appear to have inadequate power per unit of land owned. These differences are adjusted through land renting, so that power animal per unit of cultivated land is less unequal than power animal per unit of owned land of different tenure classes (Table 7).

Table 5: Work animal ownership by size of holding, 1960

Acreage Group	Percent Of total farms	Percent of farm area	Percent farms having work animal	% of work animal			Acres crop-land per animal[a]
				Bullocks	Cows	Buffaloes	
Under 0.50	13.10	1	9.7	51.8	45.1	1.1	1.23
0.50-0.99	11.20	2	27.8	48.8	49.3	1.1	1.31
1.0-2.49	27.32	13	61.8	54.0	44.6	0.9	1.31
Under 2.50	51.62	16	41.2	53.2	45.3	0.9	1.31
2.5-4.99	26.31	26	86.6	67.6	30.6	1.4	1.70
5.0-7.49	11.38	19	94.1	74.8	21.6	2.9	2.12
7.5-12.45	7.20	19	96.8	75.7	18.2	5.7	2.41

2.5-12.49	44.89	64	90.1	71.5	25.2	2.9	1.99
12.5-24.99	3.06	14	98.0	75.1	14.4	10.1	2.88
25.0-39.99	0.35	3	98.6	70.4	12.5	16.5	3.46
40.0 or more	0.08	2	94.6	66.8	11.1	21.1	5.69
12.5 or more	3.49	19	98.0	74.1	14.0	11.4	3.07
All holdings	100.00	100	65.1	67.8	28.6	3.6	1.96

a: For farms owning animals.

Source; GOP 1961

Table 6: Estimated value of work animal per head by size of farm, location and year

Size of farm	Taka per animal by location and year				
	Rangpur 1973/74	Rangpur 1974	Dinajpur 1974	Mymensingh 1974	Mymensingh 1976
Small	440	750	635	400	746
Medium	598	846	738	396	891
Large	663	955	680	428	1015
All	567	871	671	406	883

Source: GOB; Jabbar 1977; Mandal 1979

To summarize: (1) there is absolute shortage of draft power in the country as reflected in increasing use of milk and dry cows for power and the gradually degrading quality of animals due to shortage of feeds. (2) The nature of the power problem is different on different sizes of farms. The power problem is marked among small farms, a high proportion of whom do not own any power animal; those who own have the poorest quality animals, one half being cows, yet they have more power than they can use on their own land. The largest land holders have better quality animals but they seem to have inadequate power in relation to the land owned.

The causes and consequences of such pattern of animal ownership and level of mechanization are discussed below.

III. CAUSES OF NONIMPROVEMENT IN THE LEVEL OF MECHANIZATION

In the face of increasing draft power shortage, level of mechanization should have been improved by using either machines or at least improved ploughs. Instead, a lower quality power source, i.e. cows and in some cases human labour with a spade, have been increasingly used. The prevailing agrarian structure and the unavailability of suitable equipment might explain this phenomena of backward movement.

The average size of holding in Bangladesh is very small (2.30 acres in 1977) but there is a high degree of concentration in land ownership. In 1977, top 10 percent rural households owned about 50 percent of the total land; top 1.8 percent households owned 20 percent of the total land, bottom 42 percent did not own any cultivable land (Jannuzi & Peach 1977).

Most medium size land holders cultivate all land themselves. Most small land holders rent in additional land from large holders and most large land holders cultivate part of the land and rent out the rest or rent out the entire land. About 22-24 percent of the total land is cultivated under share tenancy under condition that 50 percent or less of output go to the tenant and that the tenant pays for all the inputs. Although proportion of land area under tenancy has remained almost unchanged during the last two decades, proportion of share-tenant farms has increased from around 33 percent in 1960 to over 50 percent in 1977. During the same period, landlessness increased from 17 percent to 42 percent (Jannuzi and Peach 1977).

Small and large land holders engage in sharecropping for completely different reasons but draft power has an important role in this respect. Because of the working of the law of inheritance, farm holding is getting subdivided in each subsequent generation. The degree of fragmentation is also increasing because each plot is usually divided among the heirs so that quality of land is not discriminated. Opportunity for alternative employment being limited, pressure on land is increasing. People stay on with too little land and too much labour to work on it. To utilize this excess labour, they sharecrop land from large holders. Theses farms either don't have any draft power of their own or have one or two animals of poor quality, almost half of this are cows. They use cows for draft purposes because they don't have enough capital to buy another male and not using the milk giving cow may imply inability to use their labour. They can afford to sustain with a diminished milk supply but not with a diminished crop production. The other reasons for owning a pair of work animal of whatever quality and sex are these: (1) unless one has his own pair of animals, one is not recognized as a 'farmer' and the status 'farmer' carries a lot of weight in the village society; a tenant has a higher status than an independent labourer, even selling services of animals including cows carries a higher social value than selling milk; (2) in critical sowing/planting times a pair of own animal has a premium value though it may remain idle most of the time; (3) with low saving capacity, a pair of animal may be very valuable in unusual 'rainy days'. If suitable handy machines within the purchasing capacity of the small holders were available or machines were available for hire, they probably would not go for using cows for draft.

Large land holders rent out land, partly or fully, rather than cultivating themselves because of the following reasons:

1. Land owners get more in the way of renting than what they would get by cultivating through hiring/maintaining larger number of labourers and draft animals. Since large number of tenants compete for limited land, land owners can dictate rental terms to their advantage. With improved technology, risks are higher and a large part of risk can be transferred to the tenants. Degree of tenant exploitation is higher with improved compared to traditional technology. Moreover returns from alternative investment, e.g. business, land speculation, urban housing etc. are higher than that from farming. That is why land owners go for renting rather than cultivating themselves.

Table 7: Pattern of land, fixed labour and draft power ownership by tenure status in selected samples, 1974.

Location and tenure class	Average acres owned	Average acres cultivated	Average man-units	Average No. of work animals	Acres per man - unit		Acres per animal	
					Owned	Cultivated	Owned	Cultivated
Mymensingh	6.02	4.38	1.54	2.40	3.91	2.84	2.51	1.83
Part-operator	3.57	3.57	2.12	2.47	1.68	1.68	1.45	1.45
Owner-operator	1.60	2.64	1.50	2.09	1.07	1.76	0.77	1.26
Part-tenant	3.24	3.40	1.87	2.38	1.73	1.82	1.36	1.43
All classes	7.32	3.75	2.50	2.00	2.93	1.50	3.66	1.88
	3.60	3.60	2.28	2.29	1.58	1.58	1.57	1.57
Rangpur	1.21	2.46	1.94	1.65	.62	1.27	0.73	1.49
Part-operator	3.13	3.13	2.17	1.97	1.44	1.44	1.59	1.59
Owner-operator	16.69	7.18	2.21	3.07	7.55	3.25	5.44	2.34
Part-tenant	6.31	6.31	1.79	2.39	3.52	3.52	2.64	2.64
All classes	3.14	4.77	1.60	2.37	1.96	2.96	1.32	2.01
	-	5.00	1.33	2.00	0	3.76	0	2.50
Dinajpur	9.76	6.17	1.91	2.67	5.11	3.23	3.66	2.31
Part-operator								
Owner-operator								
Part-tenant								
Tenant								
All classes								

Source: Jabbar 1977

2. With fragmented farm holdings and labour-bullock power technology, there seems to be a technical limit to the optimum size of a cultivating unit. From one study in 3 districts, the modal value of such limit appears to be 10-15 acres. In that sample 16

percent of the 300 farms owned more than 15 acres but only 7 percent cultivated 10-15 acres, none cultivated more than 15 acres. Excess land has been rented out (Jabbar 1997).

3. Fragmentation of holdings also constrain adoption and efficient use of high productive technology, e.g. irrigation, seeds etc. and thus help sharecropping to persist. There are very few land holders in Bangladesh who can independently use a 2 cusec pump or tubewell for irrigating his land. Though size may permit some farms to use, layout of the farm does not because of fragmentation. To overcome this problem irrigation systems are owned by the government and distributed to groups of farmers on a hire basis at a subsidized rate ranging from 10-100 percent. But use of irrigation increased at a much lower rate than increase in irrigation capacity. As much as 50-60 percent of capacity still remain unutilized every year. To utilize the full capacity of a 2 cusec pump or tubewell, 50-60 farmers need to come together. Socio-political conditions in the villages are such that such a large number of farms rarely work together. It has been empirically established that the districts with higher land concentration and practice of sharecropping have significantly lower use of irrigation and related technology, i.e. HYV seeds, fertilizer, insecticides etc. (Hossain 1980). Large farmers are using modern irrigation and related technology but the extent of use is limited by the available family labour and draft power on the self-managed portion of their land.

If large farms could further extend irrigated area by self-cultivation and increase cropping intensity, bullock power would become a constraint and they would look for better tillage equipment. Since irrigated area could not in fact be extended much within the present agrarian structure, demand for improved tillage equipment has not come from the large land holders. Even the meager government initiative has failed to enthuse them (see below). Rather they continue to adjust land-labour-draft power imbalances by renting out land (Table 7).

Government Programme on Mechanizing Tillage

Locally produced and imported improved ploughs, e.g. mould board, shemai, were distributed a number of times since 1935 but none of these has been adopted by the farmers primarily because the local animals are not strong enough to pull these ploughs (BARC 1975). No attempt is known to have been made to develop and manufacture any other improved tillage equipment suitable for small scale fragmented farming under both wet and dry conditions[8].

Existence of draft power shortage has been recognized since the mid sixties but the nature and dimension of shortage has never been identified or quantified[9] (see for example, GOP 1970; Lawrence 1970; GOB 1973; FAO 1977). As a result possible area of improvement also has not been properly identified. The possibility of improving the quality of animals through feeding and breeding has not been seriously taken up. The livestock sector did not receive the same kind of attention as the crop sector. Advocates of 'green revolution' seems to have ignored the fact that a neglected livestock sector might soon constrain the growth of the crop sector. Emphasis on the need for developing

livestock does not of course mean that animals could provide adequate power in the long run. But neglect of the livestock sector gave the advocates of high technology an opportunity to consider tractors and tillers as suitable substitutes for bullocks. The first batch of tractors were imported by the Department of Agriculture in the late 1950s to use on government farms. Other public organizations followed suit. Subsequently tractors were also imported with grant or tied aid and sold on credit to the private sector at subsidized prices.

The first sizeable import of power tiller occurred in 1965. Nearly 300 Japanese tillers of five different makes were imported by then EPADC for experimental purposes but subsequently disposed to the farmers. The status of tractors and tillers in 1970 given by the Pakistan Farm Mechanization Committee is shown in Table 8. The committee found the performance and farmer acceptance of both tractors and tillers as 'satisfactory' and recommended further import of tractors and tillers. The committee recommended that like irrigation pumps, Machine Pools should be created by then EPADC to make tractor services available to farmers on hire, and EPADC should build up a fleet of 8300, 16600 and 24900 tractors by 1975, 1980 and 1985 respectively. An additional 5000 tractors should be acquired by the private sector by 1985. The committee also recommended a programme of introducing 40000 power tillers in the private sector inclusive of cooperatives by 1985 (GOP 1970). As a result of the 1971 war of independence, these recommendations remained on paper.

In another report, EPADC evaluated its power tiller experiment and concluded that tillers were suitable for wet and dry land cultivation in Bangladesh. The cost of cultivation (at subsidized market price) was reported to be less than bullock cultivation and tillers could also be used for irrigation, threshing, haulage. They could work satisfactorily in small and fragmented holdings and were portable from place to place. Operation and maintenance were simple and could be picked up by the farmers themselves (EPADC 1970, quoted in Mettrick 1976).

Lawrence (1970) came to a different conclusion about the use of tractors and tillers. He claimed to have found no evidence on the positive contribution of mechanical power on crop yields and intensities. He also has shown that at market prices bullock power was 2.3 times and 3.4 times dearer than tractor and power tiller respectively but at real prices, both tillers and tractors were 2.5 times dearer compared to bullock power (Table 9). Given resource, particularly foreign exchange, constraint, maintenance problems and likely effects on income distribution and employment, Lawrence considered introduction of tillers and tractors undesirable.

Table 8: Number of tractors and tillers distributed up to 1970

		Tractor		Tiller	
Number:	Private Sector	1657	(80%)	2428	(67%)
	Public Sector	425	(20%)	143	(4%)
	Undistributed	-	-	1043	(29%)
	Total	2027	(100%)	3614	(100%)

Capacity: 20-45		60%	6.9	100%
45-55		34%		
56 and over		6%		
Size of holding of				
Private owners:				
Under 25 acres		12%	Under 15 acres	20%
25-100 "		73%	15-30	40%
Over 100 "		15%	30	40%
Average size of holding (acres)		50		31
Average size of cultivated area (acres)		36		22
Average hours worked in 1970		800		590

Source: GOP 1979

Table 9: Cost of land preparation with various sources of power in 1970

Power source	Cost per acre (Rs)	
	At market prices	At real prices
Bullock	79.00	12.00
Power tiller	23.34	31.86
Tractor	33.56	30.68

Source: Lawrence 1970

The November 1970 cyclone caused death of a large number of work animals in the coastal districts. To meet immediate power shortage, relief/aid agencies brought in 162 tractors of 4 makes and 652 tillers but half of these machines were beyond repair after only 200-300 hours of operation. To compensate loss of work animals during the 1971 war of independence, 500 tractors (200 from Britain and 300 from USSR) were received as grant/aid in 1972. Government also cash purchased 450 tillers (a different source say 648). These were distributed mainly in the border districts (GOB 1973; Mettrick 1976).

After reviewing the performance of tractors and tillers up to 1972, the Bangladesh Planning Commission concluded:

> "The experience gained up till now shows that scattered operation of tractors and tillers is likely to prove unsuccessful. Since the past records of tractor and tiller cultivation did not give conclusive results in favour of introducing large scale mechanization programme in Bangladesh and innumerable operation problems were identified, it is considered advisable to gather more meaningful data on technical and economic aspects of mechanized cultivation before launching a bigger programme" (GOB 1973).

The Planning Commission then recommended to undertake pilot experiments under farmer conditions with 20 tractors and 35 power tillers in 3 priority problem areas, such as (1) irrigated areas with multiple cropping. (2) **haor** areas where bullocks could not be used, (3) areas where cooperative societies were developed and cooperative farming was contemplated.

The proposed experiment was taken up by BADC in 1974 adding coastal area as a fourth element. Up to 1977/78, 504 tractors and 1098 tillers were collected for experimentation but during the 4 year experiment period not more than 125 tractors and 200 tillers were used in any one year. Lack of spare parts and machine servicemen, use of adulterated fuel, rough handling etc… made most machines unusable. In 1977/78, the experiment was completely abandoned and all the operable tractors and tillers have since been sold to the private sector.

The present number of operational power tiller and their performance is not known. Tillers are scattered all over the country but there are a few pockets with high tiller density. Two such pockets have been recently studied by two researchers. In one study tractors and tillers have been compared, comparison with bullock has not been reported. According to preliminary results, power tillers were reported to be more suitable for three reasons (Martius 1975, quoted in Mettrick 1976):

1. the high degree of fragmentation severely impedes the efficient used of tractors,
2. power tillers require only one-tenth of the foreign exchange of tractors and are cheaper to run and maintain.
3. tractors are only twice as productive per man day as power tillers.

Preliminary results from the other study also show power tillers as more suitable than tractors[10]. But comparison with bullocks suggest that tillers (1) do not have significant positive effect on land productivity, (2) cause net labour displacement, both directly and indirectly through labour transfer, (3) benefit the better off who can afford to buy and enjoy subsidy on the machine, and its fuel. From welfare point of view, these effects are considered undesirable (Gill 1979/80)[11]. To these points should be added the effects of ever increasing fuel prices on the relative economics of using tiller and bullock power.

It appears from the above review that the government programme on mechanization is not based on a clear understanding of the nature of the power problem existing in Bangladesh. The problem of absolute shortage of draft power on small and medium farms has received no attention in the government programme. It is wholly directed toward helping large farms to expand their scale of operation at the expense of small farms. The experiments do not provide any conclusive evidence that the machines have been widely accepted and effectively used by the farmers or that the desired effects on production have been achieved in any significant degree.

IV. CONSEQUENCES OF THE CURRENT LEVEL OF MECHANIZATION

Until about 1950, the region now constituting Bangladesh was self-sufficient in food. But a virtually stagnant agriculture in the fifties and a rate of growth of food grain production below that of population in the sixties and afterwards has turned it into a region of growing food deficit. During 1964/65-1977/78, rice and wheat production increased at the rate of 1.39 per cent, pulses and oil seeds at the rate of 0.52 per cent and

all food at the rate of 1.25 percent per annum as against population growth of around 2.6 per cent per annum. During the same period cash crop (jute, sugarcane, tobacco and cotton) production decreased at the rate of 1.53 percent, and overall crop production increased by only 0.91 per cent (Hossain 1980). Per capita production of meat and offals from livestock has decreased from 1651 mg in 1971 to 1391 mg in 1977 and that of milk and milk products from 1456 mg in 1971 to 813 mg in 1977 (FAO 1977). That means, production of carbohydrate has increased at the expense of protein, vitamins and fats. Without cows being used for draft purpose, crop production particularly food grain production would be still lower.

Draft power shortage has contributed to this slow growth through loss of potential yields, crop intensites or choice of less productive and less tillage requiring crops. Adjustment through renting does not completely solve or adjust the power problem. Large number of small farms not owning power animals could neither give optimum number of ploughing to their land nor sow/plant crops timely thus failed to derive potential intensities and yields. Large farms also face seasonal power bottlencecks when intensity reach a certain level or if land area is much higher in relation to animals. In a recent study Mandal (1979) found significantly lower yields and intensities on small and large farms compared to medium farms. He also found significantly different crop pattern on small farms compared to medium and large farms: small farms allocated a larger proportion of land to crops requiring lesser number of ploughing. He attributed these differences to, among other things, differences in availability of draft power[12].

Slow growth of agriculture also resulted in inadequate employment growth. About 30 per cent of the rural labour force is currently partly or fully unemployed and at the current rate of agricultural growth, absolute level of unemployment will grow by 2-3 percent during the next decade (Clay & Khan 1977). The contribution of draft power shortage to unemployment growth is direct. Loss of potential crop intensities and yields or choice of less productive and less tillage requiring crops due to draft power shortage means substantial loss of productive employment. If the draft power shortage would be met by rearing larger number of animals under the present system, this would also create more employment. It has been estimated that production of a 8 hour pair-day of draft power require 6 hours of man-time, i.e. the man works three fourths as much for the animals as they work for him, (Masud and Underwood 1969).

The loss of potential output and employment bear different implications for the small and the large farms, and the nation. For the large farms, it means less net earnings. For the small farms, it means less than adequate income and under nourishment; they not only loose potential crop but milk as well which normally they would consume. For the nation, it means more import or dependence on other countries for food aid.

In fact, the ever increasing food (grain, pulses, edible oils and milk) deficit are met by imports and aid. In recent years, Bangladesh has been the world's largest food aid recipient (Clay 1978). With foreign exchange earnings enough only to pay for one third of her merchandise imports, dependence of Bangladesh on food aid, not to speak of development aid, will increase if the food production problem cannot be solved, but

solving the food production problem will involve, among other things, solving the power problem.

CONCLUSIONS

The national objectives of agricultural policy in Bangladesh are: (1) to increase agriculture output, in particular attain self-sufficiency in the production of food grain, (2) to create employment opportunities in the rural areas and (3) reduce rural poverty and promote equity in income distribution (GOB 1973; GOB 1978 and GOB 1980). These objectives are considered complimentary. Therefore, the need for and desirability of improving the level of mechanization in tillage, or in agriculture in general, using one or the other technique should primarily be governed by the above objectives.

So far food grain (not all food) self-sufficiency has remained an elusive target. Consequently employment growth has been slow. On the other hand, inequality in income (and level of nutrition) has increased. The slow growth of agricultural output and employment, and the unequal distribution of income are the results of the prevailing agrarian structure. The inherent characteristics of this structure constrain the level of investment and efficient use of improved technology (see, Griffin 1976; Khan 1977; George 1978; Hossain 1980). Yet the present government policies are apparently aimed at fostering the process of polarization and develop farming in capitalist lines. This is reflected in the recent decision to sell off power pumps and deep tube wells to the private sector on credit at subsidized prices. These lumpy inputs were owned and distributed by BADC to farm groups on hire basis during the last 18 years. Sale of tillers and tractors to the private sector is also apparently directed to the same end but there has been little success so far.

Whether capitalist farming can be developed by subsidizing imported high technology is a debatable question. Even if it is possible, such a strategy directly contradicts the three complimentary national objectives stated earlier. Capitalist farming may bring some additional output but it will also create unemployment (net demand for labour will decrease) and income inequality. Unless such contradiction in policy and strategy are settled at the national level, choice of technique whether for tillage or for farming as a whole, is bound to be confusing.

With respect to improving the level of mechanization in tillage, immediate attention should be given (1) to find ways of restoring the social position of the cow as the producer of milk, (2) to find ways of improving the health of both cows and power animals. There may be several interrelated ways of doing this:

1. Bullocks/buffaloes may be used as singles provided suitable plough and harness can be developed[13]. It is already being practiced in a few thanas in Sylhet district. Naturally only the strongest of the present animals can be initially used in this way and so large farms will be the direct beneficiary. But by using strong bullocks/buffaloes as singles, the required number of power animals for tillage may be reduced by one third in a few years. Animals released by large farms may replace

milk cows on small farms. The weakest animals may be slaughtered. With total feed supply remaining constant, the health of the reduced number of animals may thus be improved. However, the technical and social possibility of using bullocks as singles has not yet been tested at the farm level even though such experiments were envisaged in the Two Year Plan (see GOB 1978). It is important that such tests should be immediately started.

2. In the Indian subcontinent there were quality draft and milk breeds. But pure draft and milk breeds are rarely available today because of cross breeding, both natural and artificial, since the British period (Sundaresan 1975; Rajapurohit 1979). Likewise the local (Bangladeshi) draft and milk breeds have lost purity. Even though pure breeds may not be available, a programme to identify good quality draft and milk breeds and practice in-breeding among these respective breeds may contribute to both higher power and milk output. This is bound to be a long term programme requiring various kinds of social control as well as promotional (educative) activities. Since it will be many years before we can get rid of bullocks as a source of power such a programme should form an essential component of both livestock development and mechanization policy. The sooner it is started is better.

3. If it is possible to start using bullocks as singles and/or selecting and breeding draft bullocks, it will require some time before the impact can be felt. Therefore, machine probably have to be introduced if cows are to be released, number of animals decreased and quality of animals is to be improved immediately. At the moment, no machine is being manufactured in Bangladesh. The newly completed Bangladesh Machine Tools Factory has facilities for production of power tillers, small tractors and a number of other machines. The National Economic Council decided in July this year that machines which can be locally manufactured should not be imported. If this decision is implemented, some machines will undoubtedly be locally manufactured in the near future, but quite a large number of tillers will still be imported because the government has already signed aid agreements to import tillers. All that can be said about these possible imports is that great care should be taken (i) in choosing size and complexity of machines to suit the small size and fragmented farming under both wet and dry conditions, (ii) in distributing to appropriate people once it is imported, (iii) in ensuring proper maintenance and operation of the machines.

It should be noted again that the imported tillers and tractors currently used in Bangladesh have been largely proved to be inappropriate under the present agrarian structure and agro-climatic conditions. Even large farms cannot use these efficiently. Without a major change in the agrarian structure more public investment on such machines will be as underutilized as pumps and tubewells but the Second Five Year Plan clearly indicate that major change in the agrarian structure is not on the agenda of the present government.

Notes:

1. Most probably information supplied by the Directorate of Livestock Services has been used. The Thana Livestock Officers are responsible for collection of

livestock statistics. Since the TLOs are not provided any facility/aid for the purpose, they do not devote enough time for collection of the figures.

Therefore, the numbers mentioned in the table should be interpreted with caution.

2. This assumption with respect to intensity of cropping may be valid up to certain level beyond which animal power may constrain further intensification of cropping.

3. Even today, cows are rarely used for ploughing in India. In 1960, only 0.46 per cent of the work animals were cows, the proportion increased to 1.5 per cent in 1972 (GOI 1976). Only Muslim farmers use cows for ploughing. Hindus don't use them because of religious sanctions.

4. Usually old, weak and 'hide bound' cattle with little alternative uses are slaughtered for meat (Shamsuddin and Hussain 1972). However, good quality cattle are also slaughtered particularly in the urban meat markets. News papers sometimes report that some cows at early stage of pregnancy are also slaughtered in the urban areas. This may happen because the sellers may not reveal that the cow is pregnant and buyers may not reveal the purpose of their buying the animal. Slaughtering in the urban areas require pre-certification by a government veterinarian. Sometimes, it is alleged that the veterinarians certify animals without physically testing them.

5. A study in a village in Thailand revealed that herds kept exclusively for breeding provided herd reproductive rate about double those of dual purpose (breeding cum-power) herds. Dual purpose livestock, therefore, puts an effective ceiling on the ability of those herds to achieve high overall reproductive rates (De Boer 19782). Johnston (1975) also notes that in developed country cattle herds about 50 per cent of animal numbers are cows while LDCs relying heavily on draft power only about 10 per cent of total animal numbers may be productive cows.
6. Based on standard tables of feedstuffs analysis and maintenance requirements the average feed intake of work animals on a sample of 40 farms in 1967 represented only 31.4 percent of the total digestible nutrients needed for a 500 pound animal (Masued and Underwood 1969).

7. "To utilize the maximum genetic potential of an animal typically requires total digestibility of the food staff of about 70 per cent. Digestibility in the range of 60-65 per cent gives intermediate performance levels while digestibility of 55 per cent (the range of most tropical forages) allows animal performance in the range of 55-60 per cent of the genetic potential of the animals. The minimum TDN for maintenance of ruminants is typically 42-45 per cent while if it falls below 40 per cent, cattle lose weight" (De Boer 1979). "The HYVs of wheat and rice typically have straw with TDN values less than 40 per cent whereas

traditional varieties generally provided straws which would at least provide maintenance requirements" (McDowell 1978).

8. Only recently, some engineers have tried to develop a neck harness with a view to derive more productive power from the existing animals with less drudgery (see, Hussain et al. 1980).

9. There are some who even now do not consider draft power as a problem. For example, Hussain (1980) estimated resource requirements for 1984/85 to achieve a 5 per cent growth in food grain production beginning from 1977/78. His list of resource does not include draft power. He implicitly assumes that additional investment in draft power will not be necessary to achieve the stated growth rate.

10. This rather general statement about the suitability of tiller need to be qualified. Tillers are suitable only if the soil has adequate moisture and if the water level in the field is not such as to submerge the engine. It is not suitable for dry season cultivation when most upland soils become very hard. Tractor seem to be more suitable to break such soils.

11. Binswanger (1979) reported by reviewing tractor studies in India that other things remaining the same, tractors are not more productive than bullocks. Irrigation with bullock is productive, but with tractor even more productive.

12. In another study, both small and large farms were found to devote larger proportion of land to 'less productive' crops and this was attributed to lack of investment ability in case of small farms and unavailability of adequate family labour in case of large farms. The question of animal power availability was ignored by saying, "since mechanized cultivation is completely absent in the area, the range of substitution between land and labour is very small in crop *once it is sown*" (Hussain 1973, emphasis added).

13. For different views and ideas on using bullocks as singles, see (Ahmed 1975; FAO 1977; Oden'hal 1978).

REFERENCES

Mosleuddin Ahmed: "Appropriate Technology-Aid to Small Farmers", in Proceedings of the Workshop on Appropriate Agricultural Technology. Dacca: BARC, 1975.

Bangladesh Agricultural Research Council: Proceedings of the Workshop on Appropriate Agricultural Technology. Dacca: 1975.

Hans P. Binswanger: The Economist of Tractors in South Asia: An Analytical Review. New York: Agricultural Development Council, Inc. (with ICRISAT, Hyderabad, India), 1978.

Hugh Brammer: "Defend Pulses against the Wheat Invation". ADAB News, VI, 11 V, (November 1979).

E.J. Clay: "Food Aid and Food Policy in Bangladesh", Bangladesh Journal of Agricultural Economics, I, 2 (December 1978).

E.J. Clay and S. Khan: Agricultural Employment and Unemployment in Bangladesh, The Next Decade. AERSS Paper No. 4. Dacca: BARC, 1977.

John De Boer and Abe Weisblant; "Livestock Component of Small Farm Systems in South and Southeast Asia". Paper presented at the International Conference on "Integrated Crop and Animal Production to Optimise Resource Utilization on Small Farms in Developing countries", Bellagio Study and Conference Centre, Lake Como, Italy, October 18-23, 1978.

A.J. De Boer: "Livestock in Farming Systems Research and Development Programs", Lecture Notes prepared for Farming Systems Workshop sponsored by Caribbean Agricultural Research and Development Institute, Port of Spain, Trinidad, April 26-27, 1979.

East Pakistan Agricultural Development Corporation: Report of the Test of Power Tilliers. Dacca: 1970 (mimeo).

FAO: Livestock and Draught Power Development. Working paper V, Government of Bangladesh and FAO/UNDP Mission. Dacca: 1977 (mimeo).

Susan George. How the Other Half Dies (The real reasons for world bunger). Middlesex, England: Penguin Books, 1978.

Md. Usman Ghani: An Analysis of the Livestock Enterprises in a Village in Mymensingh District. A Term paper submitted to the Department of Agricultural Economics, BAU, Mymensingh, in partial fulfillment of M.Sc. Ag. Econ. Degree, 1979.

Gerard J. Gill: "An Analysis of the Livestock Enterprises in a Village in Mymensingh District. A Term paper submitted to the Department of Agricultural Economics, BAU, Mymensingh, in partial fulfillment of M.Sc. Eon. Degree, 1979.

Government of the People's Republic of Bangladesh: Farm Management Research Report, Rangpur Project. Dacca: Agroeconomic Research, Ministry of Agriculture (Undated).

__: The First Five Year Plan 1973-78. Dacca: Planning Commission, 1973.

__: Statistical Pocket Book of Bangladesh. Dacca: Bangladesh Bureau of Statistics, 1977.

__: The Two Year Plan, 1978-80. Dacca: Planning Commission, 1978.

__: The Second Five Year Plan, 1980-85. Dacca: Ministry of Planning, 1980.

Government of India. Indian Livestock Census, 1972. Delhi: Government of India Press, 1976.

Government of Pakistan. Pakistan Census of Agriculture 1960. Vol. I. Karachi: 1961.

__: Farm Mechanization in East Pakistan (Report of the Farm Mechanization Committee). Rawalpindi: Ministry of Agriculture and Works, 1970.

Mahabub Hossain: "Farm Size and Productivity in Bangladesh Agriculture: A Case Study of Phulpur Farms". The Bangladesh Economic Review, II, 1 (January 1974), 469-500.

A.A. Moinul Hussain, M.D. Hussain and M.M. Hossain: "Design and Development of Neckherness for Cattle in Bangladesh". Agricultural Mechanization in Asia, XI, 1 (Winter 1980).

Land and Water Resources Sector Study, Bangladesh. Washington, D.C.: 1972.

M.A. Jabbar: "Relative Productive Efficiency of Different Tenure Classes in Selected Areas of Bangladesh". Bangladesh Development Studies, V, 1 (January 1977).

__: Land Systems in the Garo, Hajong and Santal Communities of Bangladesh. Report prepared for the University Grants Commission, May 1980.

F.T. Jannuzi and J.T. Peach: Report on the Hierarchy of Interests in Land in Bangladesh. Washington, D.C.: USAID, September 1977.

J.H. Johnston: "Conflict and Complimentarity in Asian Animal Feeding and Food Production". Paper presented at the Rockefeller Foundation Conference on the Role of Animals in the World Food Situation, New York, 1975.

A.R. Khan: "Poverty and Inequality in Rural Bangladesh", in Poverty and Landlessness in Rural Asia. Geneva: International Labour Organisation, 1977.

Roger Lawrence: Some Economic Aspects of Farm Mechanization in Pakistan. August 1970 (mimeo).

Rolf Mack: "Survey of the Present Situation of Livestock in Bangladesh (Cattle)". ADAB News, VII, 1 (January 1980).

M.A.S. Mandal: An Economic Analysis of Resource Use with Respect to Farm Size and Tenure in an Area of Bangladesh. Unpublished Ph. D. thesis, University of London, August 1979.

Hartwig Martius: Agricultural Mechanization and Rural Development in Bangladesh – An Empirical Study at Farm Level. Gottingen: University of Gottingen, 1975 (memeo).

S.M. Masud and F.L. Underwood: Power in East Pakistan Development in Bangladesh – An Empirical Study at Farm Level. Gottingen: University of Gottingen, 1975 (mimeo).

R.E. McDowell: "Feed Resources on Small Farms'. Paper presented at the Seminar on the Improvement of Farming Systems, Bamako, Mali, February 30 March 1, 1978.

H.Mettrick: Socioeconomic Aspects of Agricultural Mechanization in Bangladesh. Reading: University of Reading, Department of Agricultural Economics and Management, March 1976.

Stewart Odend'hal: Past, Present and Future Research on Livestock in Bangladesh – With Particular Emphasis on Draft Power and Mechanization. Dacca: The Ford Foundation, July 1978.

A.R. Rajapurohit: "Cross Breeding of Indian Cattle: An Evaluation". Economic and Political Weekly, XIX, 12-13 (March 1979).

A.J.M. Shamsuddin and A.M.M. Hussain: An Economic Study of Selected Primary Livestock Markets in Mymensingh and Tangail Districts. Research Report No.3. Mymensingh: Department of Cooperation and Marketing, BAU, 1972.

D. Sundaresan: Livestock Breeding in India. Delhi: Vikas Publishing House, 1975.