DEPARTMENT FOR INTERNATIONAL DEVELOPMENT

STRATEGY FOR RESEARCH ON RENEWABLE NATURAL RESOURCES

NATURAL RESOURCES SYSTEMS PROGRAMME

FINAL TECHNICAL REPORT

DFID Project Number

R 7180

Project title

OPTIONS FOR USE OF POWER TILLERS AND DRAUGHT ANIMALS FOR PRIMARY CULTIVATION ON SMALL FARMS IN BANGLADESH.

VOLUME 1 : MAIN REPORT.

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NRSP Production System

High Potential

Date

13th. December 2000

CONTENTS

1. Executive Summary

Project purpose

The NRSP programme logframes have been revised since the start of this project, and with the increased emphasis on poverty elimination the project purpose was re-directed from "efficient management of labour and farm power" to "the development of efficient rural services to the poor". However, this particular research project can only fulfil that revised purpose by virtue of its place within the new NRSP logframe and its links with the DFID bilateral REFPI ("Strengthening Institutional Capability for Research and Extension in Farm Power Issues") project. The project being reported on did not include an assessment of the efficiency of existing rural services for mechanisation, because it had not been asked to do so, but rather presents an analysis of the issues surrounding the impact of the Bangladeshi model of mechanisation of cultivation ("PT-isation"): the findings are to be taken forward by subsequent HIPPS Output 2 projects and REFPI.

OVI's at purpose level

The first OVI for Output 2 of the new Programme logframe is that knowledge constraints to the delivery of rural services essential to the livelihoods of the poor are identified and disseminated. This project has re-oriented its investigations towards the interests of the poor and the findings and conclusions provide useful indicators of attainment of addressing knowledge constraints by the time specified in the logframe (2001). However, the second OVI, that by 2003 cost efficient delivery systems have been adopted, has not been tackled by this project.

Project outputs

The outputs have documented farm power use and the impact of mechanised cultivation on agronomic, farming system and socio-economic practices, examined policy options, formulated recommendations and disseminated the findings through appropriate local and international channels.

Project activities

These have included:

- A literature review
- Baseline and weekly agricultural and socio-economic surveys
- Field days for participating farmers
- Data analysis and reporting
- Supplementary PRA's
- Scientific workshops in 1999 and 2000
- Scientific papers and media support material
- Contacting NGO's to "seed" pro-poor projects

Attainment of NRSP purpose

The NRSP programme purpose is that "*benefits for poor people in Bangladesh are generated by application of new knowledge to natural resources management"*.

The project findings have been brought to the attention of the Bangladesh research community and local government agricultural staff, some relevant members of the local

commercial sector and the wider farming community in the project area as well as national and local NGO's. The findings have also fed directly into the bilateral development REFPI project. The latter, being funded by DFID, can be assumed to have a pro-poor agenda. It is however a significant assumption of this project that the other institutions are pro-poor oriented. The presence of projects like this one is intended to reinforce such commitment.

Dissemination outputs (leaflets and video) are intended to be given wide circulation within Bangladesh and it is hoped that this will be a means of gaining access to a wider audience of senior officials whose decisions will affect the livelihoods of the poor.

(498 words)

2. Background

The project set out originally with the goal of increasing the production of agricultural commodities in the farming systems of Bangladesh. With virtually the entire possible arable area of Bangladesh under cultivation, it is apparent that increased production must be achieved through greater cropping intensity (more than one crop per year) or through increased yields per unit area. A constraint to achieving this, which is the subject of this research project, has been identified as shortage of draught power, formerly provided mostly by cattle (Mettrick and James, 1981; Hermans, 1984; ULG, 1986; Daniels, 1987). This is the result of reduced land and feed resources and increased demand for draught power at peak periods. One solution has been to increase the use of cows for draught (Matthewman, 1987; Matthewman and Foulds, 1988). A further solution, and one which has become widespread in recent years, superseding the former solution to a great extent, has been to mechanise cultivation, by the use of power tillers, since these can cultivate more quickly than draught animals (Pallis et al, 1983; Bunyavejchewin *et al*, 1993), but a number of potential problems may arise. Draught animals have traditionally provided family security, manure and income from calves or rental and have been used for threshing and out of season uses such as transport, as well as cultivation. The adoption of power tillers may thus disturb the existing asset bases of farmers and also have direct effects on production through changes in the maintenance of soil fertility.

Under the revised, pro-poor, programme rationale, the benefits of increased production are intended to accrue to the poor. It has therefore been necessary to form an understanding of the livelihood strategies of the poor in order to ascertain how they may have access to such production increases. It is desirable that the benefits of the solutions to draught power shortages adopted, particularly mechanisation of cultivation operations (by use of power tillers – "PT-isation"), outweigh the negative effects. The available literature indicated there had been little investigation of the impact of the use of mechanical sources of power for small farming in Bangladesh since Gill's major study in the early 1980's (Gill 1984) and that of Jabbar *et al*. (1983). These studies indicated that the use of PTs, while profitable for their owners, seriously affected the incomes of marginal farmers, sharecroppers and landless labourers while contributing little to the overall productivity of the farming system. This research aimed to address these issues which are of crucial importance in Bangladesh where poverty remains the single most important social and economic challenge facing the country. The project therefore sought to determine the effective present balance of effects and draw forth lessons for the operation of policy and support services for the poor in the changing circumstances which the form of mechanisation prevalent in Bangladesh - PT-isation - represents.

Great changes in the cropping systems in Bangladesh have come about over the last 20-30 years with the widespread use of irrigation from both deep tubewells (DTWs) and shallow tubewells (STWs) for dry season (winter) irrigation of rice and largely as a result of

this the cropping intensities of nearly all parts of the country showed considerable increases over this period (Table 1).

Table 1. Multiple cropping indices (cropping intensities) for Bangladesh

	1960	1980	1998-9	
	National	National	National	Project farmers
Small (0-2.5 ac.)	167	181	n/a	167 – 207[1]
Medium (2.51- 7.5 ac.)	152	167	n/a	189 – 200[2]
Large (>7.5 ac.)	135	152	n/a	190 - 200[3]
Average	n/a	165	176	195

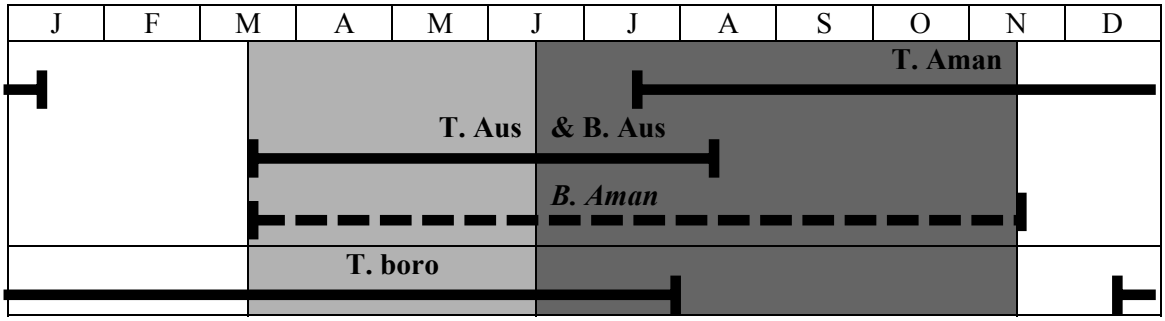
Sources: Gill (1983), Eunus (2000a) and Ershadul Haque (2000b)

[1] Landless, marginal & small category (<2.5 ac.); [2] Medium category (2.51 – 5.0 ac.) ; [3] Large category (>5.0 ac).

Before winter irrigation, the principal cropping systems in most parts of the country were based on *Aus* rice (planted March-May in the early rains or *Kharif-1* season) and *Aman* rice (planted July-September in the mid-to late- rains or *Kharif-2* season). Since the advent of irrigation, the pattern has changed to *Aman – Boro*, the latter being the irrigated crop planted out in December to April during the dry winter *(Rabi)* season (most of the rice crops are transplanted and prefixed *"T"*, although some are broadcast , prefixed *"B"*). The cropping calendars for rice, that is *Aus, Aman, Boro* and the usually geographically separate system of deep water rice – carried out on the coastal and permanent water body margins of the country - are complex and largely determine the demand for draught power (Richards, 1979). Peak demand coincides with the turn-around time between crops. Timeliness in cultivation at these times is critical (Orr *et al*, 1986), placing a heavy demand on power resources. But the changed cropping pattern cited above has ramifications in the timing and pressure on cultivation power sources and has been investigated under the project.

The cropping patterns are shown in the diagram below.

Figure 1. Generalised cropping calendar for principal rice-based farming systems in Bangladesh.



Seasons — Rice crops

Rabi — T. boro (transplanted boro rice), 130-day growing season, transplanted between 1 December and 15 April.

Kharif-1 — T. aus (transplanted aus rice), 100-day growing season, transpl. 15 March - 30 April. B. aus (broadcast aus rice) approx. same growing season. B. aman, (deepwater rice), longer season.

Kharif-2 — T. aman (transplanted aman rice), growing season about 130 days, transplanted 15 July - 30 August.

Source: Project Literature review, modified from Sims (1994).

It is necessary to know what the decrease in use of draught animals will mean in terms of release of farm resources for other livestock enterprises, pressures for the use of cows for draught, the resulting changes in seasonal patterns of demand for draught animals and the implications for feeding systems and husbandry of draught animals. There is also the possibility that adoption of power tillers by wealthier farmers may have a negative effect on draught animal owners, because a further reduction in draught animal ownership could create fertility problems because of the lack of availability of bulls, as identified by Mettrick and James (1981).

Hence, the implications and opportunities (including the effect on crop yields) that arise from an increased use of power tillers have been investigated at the farm level and with farmers in different circumstances, in different cropping systems and with different farm size, capital inputs and labour availability. The results will help in the planning of improved extension inputs and support for power tiller and draught animal use and development.

The present project was submitted to NRSP in parallel with a bilateral project on the use of farm power in Bangladesh, which took off in 1999 as REFPI. In addition, other proposed research in Bangladesh by the Bangladesh Livestock Research Institute includes investigations of feed availability and the development of strategies to increase and intensify livestock production on farms. The present study will complement these studies by investigating the effect of power tiller adoption on draught animal supply and demand and the resultant effects on farm resource use for livestock.

3. Project Purpose

The project's purpose was to develop and promote strategies to increase crop and livestock production on small farms through the provision of appropriate combinations of farm power from power tillers and draught animals by providing a better understanding of the long term consequences of decisions on the use of tillers or draught animals. The project investigated current trends in farm power usage and the long-term impact on the poorest members of society, particularly share croppers, landless labour and tenants.

The analysis of the issues surrounding the impact of the Bangladeshi model of mechanisation of cultivation ("PT-isation") was intended to provide an understanding of effects of the changes in a sample area, which could be extrapolated to the national scene and used in the formulation of advice and policies for support and services to the rural poor.

From figures obtained from the Department of Agricultural Extension it was found that the districts where the sample villages are situated, Tangail and Mymensingh, rank 8th. and 10th. respectively out of the 64 districts of Bangladesh in terms of numbers of PTs. It may thus be inferred that the study area offers a picture of a well advanced state of PT-isation compared to the national situation. Thus what is found true for the sample may be taken as a possible preview of the situation to come in other less PT-ised districts if circumstances which favour PT-isation do not change. (In terms of numbers of 4-wheel tractors, the districts are less advanced, Tangail having only 10 – 22nd. in rank - and Mymensingh having none at all recorded).

The sampled farms also have a higher level of cropping intensity (multiple cropping index) than the national average, as shown above in table 1. The national average is lowered by the lower levels of intensity possible on the basin systems which make up about 5% of the surface area of the country. It would appear, however, that the level of multiple cropping is relatively high in the study area. Whether this is affected by the use of PTs was one of the topics investigated by the project.

In terms of the representativeness of the agro-ecological zone (AEZ), the Old Brahmaputra Floodplain AEZ 9, in which the villages are located, occupies some 5% of the land area and is ranked as the 8th. largest in the country. It bears resemblance in terms of land type (elevation and soils) to other AEZ's in the Ganges[1] and Karatoya – Bangali flood plains, which, together with the Old Brahmaputra flood plain, occupy some 21% of the country's land area.

4. Outputs

Output 1. Existing use of animal and mechanical power in small farms documented.

A baseline survey of 198 households[2] was undertaken to establish the extent of PT use in study villages as well as land ownership patterns, tenure and access to land of the different categories of farmers. Landless, marginal and small, medium and large farmers had average holdings of cultivable land of 0.70, 1.02 and 1.94, 2.38 and 4.44 acres respectively.

Availability of farm power

The sample farmers owned a total of 17 PTs and 145 draught animals. They had a total of 422 permanent male workers at their disposal (including family labour) (Table 2).

Table 2. Distribution of PT, DA and human labour (sample farmers only)

Name of village	No. of working person (male)	Permanent employed labour (male)	No. draught Animals	No. of PTs
Pakutia	86	-	19	4
Jhunkail	93	6	55	6
Sangramshimul	38	5	11	2
Golabari	57	4	33	1
Satrasia	62	8	6	2
Kumargata	58	5	21	2
Total	394	28	145	17

Source: Baseline survey data reported in Workshop Proceedings Volume 2 10th July, 1999

The estimated power available to sample farmers in the six villages is shown in Table 3, excluding casual or migrant labour. Calculations are based on the following parameters:

- PT= 7 kW,
- Male DA= 0.18 kW
- Female DA = O.15 kW
- Male human = 0.06 kW
- Cropping intensity is 215 percent.

[1] The Ganges flood plain soils are, however, more alkaline

[2] See Workshop on Presentation and Review of PRA and Baseline Survey Finding. Volume 2: Proceedings and Summary of Findings. BAU, 10th July, 1999. Details of methodology, sampling etc. are in **Section 5 Activities.**

Table 3. Distribution of power available in the study area (sample farmers only)

Name of village	Total cultivable land area (ha)	Power from working person (kW)	Power from draught animal (kW)	Power from power tiller (kW)	Power available/ha (kW/ha)
Pakutia	67.64	5.16	3.14	28.00	0.53
Jhunkail	64.47	5.94	9.08	42.00	0.88
Sangramshimul	35.22	2.58	1.82	14.00	0.52
Golabari	47.67	3.66	5.45	7.00	0.34
Satrasia	52.55	4.20	0.99	14.00	0.37
Kumargata	74.11	3.78	3.47	14.00	0.29
Total	**341.66**	**25.32**	**23.95**	**119.00**	**0.49**
Contribution for land preparation (%)		15.05	14.22	70.73	

Source: Baseline survey data reported in Workshop Proceedings Volume 2 10th July, 1999

The total power available per hectare on sample farms was higher than the national average (0.39kW/ha, Sarker, 1997) as a result of a high concentration of PTs in the study area. Table 4 demonstrates that the majority of farmers - 177 (89%) use PTs for land preparation. The growth in the use of PTs for land preparation was confirmed during a participatory exercise undertaken in 1999. The six villages collaborating with the research reported that the total number of PTs had increased from 13 in 1995 to 36 in 1999 (Islam and Sarker, 2000).

Table 4. Use of PTs and DAs by sample farmers (no. of farmers using each source of power)

	Landless	Marginal	Small	Medium	Large	Total
Own oxen	5	6	6	10	6	33
Own cows	9	9	12	9	5	44
Rented oxen	2	2	3	2	1	10
Rented cows	1	0	0	0	0	1
Own PT	4	6	0	4	5	19
Rented PT	41	37	32	31	17	158

Source: Baseline survey data reported in Workshop Proceedings Volume 2 10th July, 1999

The weekly survey[3] collected information about all inputs used (including power) on 482 plots over a period of 15 months. Figures 2 and 3 and Table 5 demonstrate that the majority of farmers use PTs for land preparation. Only 27 farmers used DAP exclusively although many used a combination of PTs and DAs.

[3] Weekly Survey methodology is described in **Section 5 Activities.**

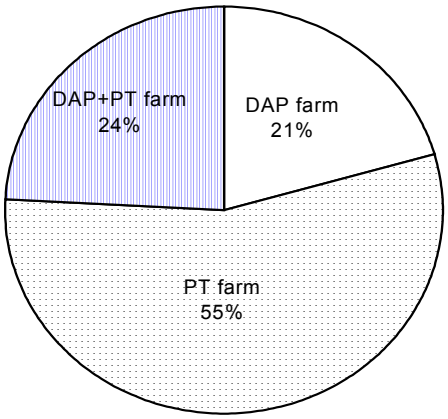


Figure 2. Distribution of Power Options of Boro Plots

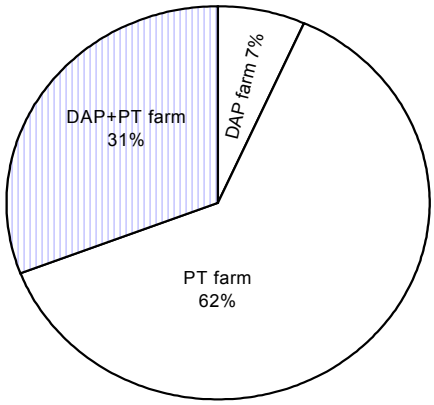


Figure 3. Distribution of Power Options of Aman Plots

Table 5. Types of power used on plots surveyed during the weekly survey

	DA	Both	PT	All
Village:				
Pakutia	8	57	33	98
Jhunkail	8	73	17	98
Sangram Shimul		14	50	64
Golabari	9	49	16	74
Satrashia		6	68	74
Kumargata	2	23	49	74
Farm category:				
Landless	3	15	34	52
Marginal	12	34	58	104
Small	6	72	42	120
Medium	6	51	39	96
Large		50	60	110
All	27	222	233	482

The research has established that the adoption of PTs is widespread (in the study area) and the machines are used by all sizes of farm. PTs are **not** only used by the larger farmers which was formerly the case (Gill, 1984). PT cultivation is perceived to be faster than that with DAs and given that installed capacity is increasing , queuing for contract services (as reported by Gill, 1984) may be a thing of the past.

Output 2. The impact of mechanised cultivation and draft animal power on: land and labour productivity, landless labour, yields, incomes and food security, and landlord/tenant relations quantified.

Profitability

Yields and returns

PTs have little impact on rice yields (Table 6). Although PT users have statistically significant higher yields that DAP users for Boro rice, the increase is small. Yields of Aman

rice were similar for both power sources. Yields were more closely associated with choice of variety and fertiliser use (urea) both of which had a positive impact upon yield (Haque, 2000).

Table 6. Impact on yields and returns

Boro Rice

Power source	DAP	PT	Both
Yield (kg/ha)	5307	5385	5483
Gross Return (Tk/ha)	38635	39202	39916
Net Return (Tk/ha)	8774	12785	12641
BCR (undiscounted)	1.29	1.48	1.46

Aman Rice

Power source	DAP	PT	Both
Yield (kg/ha)	3540	3580	3530
Gross Return (Tk/ha)	26373	26671	26298
Net Return (Tk/ha)	12373	13746	13388
BCR (undiscounted)	1.88	2.06	2.04

Source: Barton, (2000) drawing on weekly survey data presented by Ershadul Haque, 2000a and Miah, 2000.

PTs improve farmers' gross margins as production costs decrease (Table 6) (mechanical cultivation uses less human labour than DAP cultivation) (Miah, 2000). PT users are therefore likely to have higher incomes than DAP users (per unit of production). They also have the effect of reducing the management required for production (supervision costs are reduced) and also probably reduce the labour and management required to maintain draught animals. These savings are of greater importance to larger farmers. The major benefits accruing to smaller enterprises are reduced production costs but hiring PTs also reduces the need for smaller farmers to maintain draught animals.

Labour productivity and use

The use of PTs in rice production improves labour productivity (the yield or quantity of grain produced by each unit of labour) (Table 7).

Table 7. Labour productivity

Boro

Power source	Human labour (hrs/ha)	Yield (kg/ha)	Yield per unit of human labour (kg/hr)
DAP	1431	5307	3.70
PT	1212	5385	4.44
Difference PT - DAP	-219	+78	+0.74

Aman

Power source	Human labour (hrs/ha)	Yield (kg/ha)	Yield per unit of human labour (kg/hr)
DAP	1184	3540	2.99
PT	1015	3580	3.53
Difference PT - DAP	-169	+40	+0.54

Source: Barton, (2000) drawing on weekly survey data presented by Ershadul Haque, 2000a.

The increase in the productivity of labour with the adoption of PTs is 20% for Boro and 18% for Aman.

Family labour

The use of PTs for land preparation is associated with increases in the demand for hired labour and reductions in the use of family labour (Ershadul Haque and Sarker, 2000). It is not clear whether family labour is redeployed elsewhere or benefits from increased leisure

time. Despite being a labour saving technology - it reduces the human labour required for land preparation - the introduction of PTs has probably provided employment opportunities for labourers. Farms using DAP for land preparation use equal amounts of family and hired labour whereas PT farms use twice as much hired labour as family labour.

Landless Labour

Participatory exercises with landless labourers confirmed that PTs reduce daily wage labour employment opportunities for land preparation (ploughing with DAs). Larger farmers also reduce the number of permanent labourers they employ (there is less need to maintain draught animals). However, the increase in the availability of irrigation water has altered cropping patterns and increased the demand for labour for transplanting and harvesting. Labourers also reported an increase in non-farm employment opportunities (where wages are higher) and an increase in the real value of wages over the past decade (Islam and Sarker, 2000). On balance they felt their livelihoods had improved following the introduction of PTs, (although this was not a causal relationship).

Landlord/tenant relations

Earlier research in the field of agricultural mechanisation (PTs) in Bangladesh reported that the adoption of PTs reduced opportunities for sharecropping as landlord 'took in hand' land that was formerly let to tenants (Gill, 1984). Participatory research undertaken by this project indicates that this is no longer the case (Islam and Sarker, 2000).

Table 8 shows the changes in size of holding of sharecroppers in each village after the introduction of PTs. With the exception of Sangram Shimul, total cultivable land of sharecroppers has increased following mechanisation (most of the farmers in Sangram Shimul are resource poor farmers with little land available to let). Land available to sharecroppers has increased for the following reasons:

- Cost of production increases has discouraged landlords from cultivating their own land or to acquire more land to sharecrop with others.
- The supply of available labour is often insufficient and labour wages therefore increase. Consequently, larger farmers prefer to rent out land to sharecroppers.
- The number of absentee landlords may have increased (migration), thus improving the opportunities for sharecropping.

Table 8. Changes in size of land holding of sharecroppers after introduction of power tillers (ha)

Village	Before introducing PT, 1988			After introducing PT, 1999			Differ-ence in size of holding (±)
	Land rented in	Land owned	Total	Land rented in	Land owned	Total	
Pakutia, n=10	2.570	0.425	2.996	3.198	0.425	3.623	0.627
Jhunkail, n=10	3.259	0.834	4.093	3.320	0.834	4.154	0.060
Sangram Shimul, n=5	1.880	0.182	2.064	1.032	0.170	1.202	-0.862
Golabari, n=6	0.770	1.032	1.801	1.214	0.607	1.821	0.020
Satrasia, n=6	2.093	1.391	3.484	2.222	1.645	3.868	0.385
Kumargata, n=6	0.878	1.615	2.494	1.599	0.901	2.500	0.006
Total of all locations, n=43	11.453	5.479	16.933	12.587	4.583	17.170	0.237
Average of all locations	1.908	0.913	2.822	2.097	0.764	2.862	0.040
Percentage of total in each year	67.64	32.36	-	73.31	26.69	-	-

However, it is DAP owners rather than PT owners or users who have been offered more land for sharecropping. Landlords appreciate the benefits of organic material (manure)

and anticipate higher yields from the use of DAP. Ownership or access to DAP (and manure) may be a precondition for access to rented land (sharecropping).

Labour opportunities directly generated by PT adoption.

Within the study area, in the village of Pakutia, small-scale manufacturing shops have developed, mainly for the production of share tines from recycled metal scrap. These products are marketed nationally, thus the industry is not necessarily replicable in other areas of PT-isation. Some 60 people occupied in this trade were interviewed. Most were previously employed as farm labourers and a few had been sharecroppers. The majority received informal on-the-job training rather than any formal training course. On average, they were earning about twice the sum they had gained from their previous occupation and had increased their working days from 200 to 295 per year. Nearly all said that their living standard had been improved, 80% that the numbers of their children going to school had increased, and 56% that their social status had been improved (Islam, 2000).

Output 3. The impact of mechanised cultivation on cattle production, energy use and soil fertility analysed.

Cattle production

The introduction of PTs has had a significant impact on the numbers of cattle kept by farmers. The baseline survey indicated a steady decline as farmers withdrew draught animals from their farms (Table 9). Following analysis of this data it was hypothesised that cattle would be more productive than formerly, as they would have access to similar amounts of fodder. However, PRA with cattle owners suggested that this was not the case. Table 9 outlines the importance attached by farmers to the different types of production associated with cattle and is a summary and average score of cattle owners from the six study area villages.

Table 9. Time series data on cattle ownership 1994-98 (sample 198)

Year	1994	1995	1996	1997	1998
Draught oxen	160	155	116	87	68
Draught cows	142	136	114	93	87
Milk cows	99	115	100	99	94
Calves	77	79	72	91	
Buffaloes	4	2	2	0	0

Source: Baseline survey data reported in Workshop Proceedings Volume 2 10th July, 1999

Participants in the 2000 PRA were asked to rank the importance of different production objectives for each type of cattle (e.g. draught for cultivation, milk for domestic consumption and sale; meat for domestic consumption and sale; cash (income) and savings; manure production and replacement stock). Table 10 refers.

Table 10. Preference matrix of livestock production objectives of cattle owners

Type of cattle	Draught	Milk		Meat		Cash/ Savings	Manure	Replace-ment
		Consump-tion	Sales	Consump-tion	Sales			
Bulls/bullocks	7	0	0	2	3	3	6	0
Cows	5	6	5	3	4	2	6	0
Bull calves	1	0	0	0	0	6	2	7
Heifers	1	1	1	0	0	1	2	10

Source: PRA results reported by Islam and Sarker, 2000.

Farmers keeping male cattle placed a high value on draught although manure is considered to be a valuable output. Cows are kept primarily for milk (domestic consumption), manure and income (milk sales). More than 80% farmers reported that at present they keep less cattle because PTs are easily available and cheaper to use for cultivation. With intensive cultivation (irrigated boro rice), farmers have higher yields of both grain and straw and a greater volume of straw per head of cattle owned. Some farmers (18%) regularly plough a portion of rice straw back into the field and other sell straw that is surplus to their needs. However, changes to cropping patterns (the introduction of boro rice) have reduced the availability of legume fodders during *Rabi* season which has affected meat and milk production from both cows and other ruminants. About 58% farmers continue to rear cows for dual purpose, milk and draught despite the presence of PTs (for hire). Perhaps they act as an insurance against machinery breakdowns. Meat production was the third preferred purpose of the cattle owners (25%) although there was no evidence of intensive meat (or milk) production. Cattle dung was used as manure and fuel, and more than 50% farmers of six villages reported it as an important output from cattle husbandry.

Energy use

PTs contributed more than 80% of all energy for land preparation for rice production. Major sources of energy include irrigation water, fertiliser and manure. The use of PTs does not have a statistically significant impact on energy use at the farm level (Sarker, 2000) and PTs make little impact on overall energy budgets. Table 11 refers.

Table 11. Energy inputs, outputs and ratios (MJ/ha)

Crop		DA	PT	Both
Boro rice	Input	18235	18024	18415
	Output	114260	115764	113402
	Ratio	6.27	6.42	6.16
Aman rice	Input	4179	4273	4327
	Output	106318	105699	105699
	Ratio	25.44	24.43	24.43

Source: Sarker, 2000

Soil fertility

Mechanised cultivation is perceived by farmers to have an indirect effect on soil fertility. Most of the farmers (77%) of the survey areas reported that soil fertility has decreased due to less use of organic fertiliser. Manure is the main source of organic fertiliser and is generally in short supply and supplies are declining in line with the changes in cattle populations. It proved beyond the means of the project to undertake a scientific assessment of the impact of PTs on actual soil fertility.

However, researchers in Bangladesh have observed that soil physio-chemical characteristics are affected by different types of power sources used (DAP and PT) which ultimately affect the foil fertility. In one experiment at BAU soil bulk density and organic matter content were found to be highest under few cultivation passes with DAP, while the lowest values of both variables were found with multiple passes by PT. Soil moisture content and soil porosity were however higher under the multiple PT pass treatment. But grain yields of wheat under the different tillage treatments did not differ significantly. In another experiment on the BAU farm using *aman* rice as the test crop significantly higher grain yield resulted from the use of country plough (DAP) and power tiller with multiple passes compared to both forms of tillage with only one or two passes. In this experiment however, soil physical and chemical properties did not differ significantly between treatments. These trials are described by Eunus, Basunia and Islam (2000) and together with other trials are

reviewed in a general paper written in part for this project by Eunus (2000a). There is scope for more work on the issue, including long-term on-farm trials.

Output 4. Policy options to optimise use of farm resources through soil fertility maintenance and increasing productivity of livestock and crops examined and presented.

PTs have the following impact on AEZ-9 farming systems of Bangladesh:

- Little or no impact on yields or energy use
- A possible reduction in turnaround time between the two rice crops (Ershadul Haque, 2000b) and therefore improved timeliness
- A reduction in the costs of production for all sizes of farm
- Higher gross margins for all sizes of farm
- Greater labour productivity for all sizes of farm
- Increased demand for hired labour
- Appears to increase opportunities for sharecropping
- Releases fodder (roughage) for animal production.

It is concluded that the impact of PTs has been positive both in terms of its social and economic impacts. Therefore policy makers can be assured that the promotion of mechanised land preparation in the form of PT-isation as operating presently in Bangladesh will not have negative social and economic impacts. This message should form the basis of mechanisation extension messages. Mechanisation of other tasks such as transplanting and harvesting are much more likely to have negative social effects, given that these are the most labour demanding tasks.

PTs are profitable investments for their owners even under circumstances of increasing fuel prices (10% increase in operation and management costs) (Miah, 2000a). Investment in PTs is likely to continue unless operational and management costs increase by 20% or gross benefits decrease by a similar amount.

Output 5. Recommendations on farm power for extension services developed and disseminated through appropriate local and international channels.

The project researchers co-operated throughout the field work with local Ministry of Agriculture Department of Agricultural Extension (DAE) staff, principally the Block Supervisors. These are the front-line extension staff whose clientele in this area range from 900 – 1600 farming families in 2 to 11 villages. Advice and information on the selection of villages was obtained from them at the onset of the project field work. The block supervisors and senior officials of the Ministry also attended the two project workshops held in 1999 and 2000.

Following the 2000 workshop a leaflet was prepared for circulation to DAE staff throughout the country. The purpose of the leaflet is to describe the project findings and for it to be used in extension to stimulate discussion of the issues, potentially leading to further training. The leaflet describes the findings on yields, returns, labour use, cattle production, and the contribution of PT-isation to sustainable livelihoods. The conclusion made is that, on balance, the overall impact of the use of power tillers has been positive both in terms of economic value and social effects.

Therefore planners and policy makers should not be seriously concerned about the impact of PT mechanisation on the poor because:

- All farmers and labourers can benefit from mechanisation.
- Farm incomes improve
- Landless labourers benefit from improved employment opportunities
- Cattle numbers decline which provides opportunities to intensify production.

The leaflet is presented here as in the Annexes (volume 2).

A video film is in preparation by a local media team with a similar intention but intended for use in direct showing to farmers to stimulate discussion of the issues.

A Director and representative of the national NGO PROSHIKA attended the 2000 workshop and expressed interest in co-operating on the distribution of pedal threshers on an easy loan basis to those landless labourers and sharecroppers with which the project had co-operated. Unfortunately the follow-up and confirmation from them was delayed and the distribution will now take place through several local NGO's, who had also been represented at the workshop. The 2000 workshop was also attended by local machinery dealers.

The local project economist, Professor Miah, conducted a sensitivity analysis on the possible impact of fuel and machinery cost increases or decreases in gross returns on the profitability of PTs and concluded that the investment on PTs would no longer be a profitable business if O & M costs increase by 20.0 per cent or gross benefits decrease by 20.0 per cent. This reveals a rather unstable profitability and the findings should be communicated to national government representatives. His paper is given in the Annexes (volume 2).

Two papers for international journals are in preparation, for *Agricultural Systems* and *Agricultural Mechanisation in Asia*.

5. Research Activities

Literature Review

M.G. Adam & D. Barton (1999) Farm Power for Cultivation in Bangladesh: a Review of the Literature. NRI Report No 6414.

The review was compiled by the UK collaborators from materials provided by project collaborators in Bangladesh and from materials sourced in UK. It was international in scope and included the experiences of other SE Asian countries.

Rapid Appraisal and Baseline Survey

At the outset of the project a rapid appraisal (referred to in the report of its activities as a PRA) was undertaken by project researchers to identify collaborators (farmers and local Department of Agricultural Extension staff). Six villages were selected in 3 Thanas (now called Upazillas) and two districts (Mymensingh and Tangail) as they displayed a degree of mechanisation suitable for investigation.

For the baseline survey a total of 198 farmers were selected using a stratified random sampling technique using 5 farm categories in each village as five strata (see table 12). To collect information using a pre-planned and pre-tested schedule of relevant questions one well-qualified and trained enumerator was located in each village.

Table 12. Distribution of selected farmers by village and farmer category

	Landless	Marginal	Small	Medium	Large	All categories
Pakutia	10	10	8	8	4	40
Junkail	10	10	8	8	4	40
Sangram Shimul	8	8	6	4	4	30
Golabari	8	8	6	4	2	28
Satrasia	8	8	6	4	4	30
Kumargata	8	8	6	4	4	30
All villages	52	52	40	32	22	198

Source: Ershadul Haque, 1999

Weekly Survey

A weekly survey was designed to collect information from 482 pre-selected plots of the sample farmers, a visit was made each week for a period of 13 months to record all farm activities on these plots (January 1999 to March 2000). The main objectives of this survey were to quantify the impact of PTs on land and labour productivity, labour use, yields, margins, and energy use.

A two way (village and farm category) stratified sampling technique was followed (Table 13). The sample sizes for different strata (a combination of a village and a farm category) were not proportional to the corresponding population sizes but were determined by subjective allocation (considering size, heterogeneity and availability of project resources). A total of 482 plots were chosen for the weekly survey (Table 13). Enumerators recorded all farm activities done on these plots for each crop over a period of 13 months. They visited each plot with the farmer and recorded data on the provided schedules/questionnaires.

Table 13: The distribution of number of sample plots by village and farm category

	Pakutia	Jhunkail	S. Shimul	Golabari	Satrashia	Kumargata	All
Landless	10	10	8	8	8	8	52
Marginal	20	20	16	16	16	16	104
Small	24	24	18	18	18	18	120
Medium	24	24	12	12	12	12	96
Large	20	20	10	20	20	20	110
All	98	98	64	74	74	74	482

Source: Ershadul Haque, 2000

More than 100 separate pieces of data (variables) were collected for each plot, including:

- Area, soil-type, topography and ownership of the plot, variety
- Human labour used (in hrs) by its source (e.g. family, hired, male, female, casual, permanent) for the following operations cleaning, ploughing, laddering, seedling transfer, sowing, transplanting, irrigation, application of fertiliser, pesticides and herbicides, harvesting, transport and threshing.
- Animal labour used (in hrs) for ploughing, laddering, transport, threshing etc. Types of animal used (a pair of cows, bulls, or mixed)
- PT hours used for ploughing, laddering, transport, threshing
- Material inputs (quantity and cost): Seed, Manure, Urea, TSP, SSP, MP, Zinc, Gypsum, Pesticides, herbicides, fuel, electricity etc.
- Outputs : grain and straw

Table 14 shows the number of plots of different crops surveyed.

Table 14. Number of respondents/plots for the weekly survey

	Year	Village						All
		Pakutia	Jhunkail	S. Shimul	Golabari	Satrashia	Kumargata	
Weekly Survey								
Boro	1999	98	95	61	72	61	7	394
Wheat	1999		3		2	2	24	31
Jute	1999		2			7	35	44
Mustard	1999						4	4
Tishi	1999						1	1
Sunflower	1999						1	1
Pulse	1999						2	2
Potato	1999						2	2
Snakegourd	1999			3				3
Aman	1999	93	93	64	66	63	70	449
Mustard	2000	3	3	10	7		1	24
Wheat	2000					2	28	30
Boro	2000	98	94	64	73	60	7	396

Source: Ershadul Haque, 2000

PRA of selected groups

The purpose of this PRA was to explore the impact of PTs on landless labourers, sharecroppers and cattle owners/production. A total of 130 participants were selected (40 landless labourers, 43 sharecroppers and 47 cattle owners). The distribution of participants by village and category is shown in Table 15. The PRA was carried out by project research enumerators under the supervision of both local and UK researchers.

Table 15. Distribution of participants in the ("second") PRA by village and category

	Pakutia	Jhunkail	S. Shimul	Golabari	Satrashia	Kumargata	All
Labourers	7	8	8	6	5	6	40
Sharecroppers	10	10	5	6	6	6	43
Cattle owner	8	9	8	9	6	7	47
All	25	27	21	21	17	20	130

Source: Ershadul Haque, 2000

Participatory techniques were used with 3 groups of each of the 3 categories in each village.

Blacksmith Survey

A sample survey of 60 blacksmiths engaged in the manufacture of spare parts for PTs was carried out in Pakutia village by one of the project field enumerators under the supervision of the local socio-economist researcher.

Workshops

Two workshops were held (1999 and 2000) where research findings were presented to audiences consisting of representatives of:

- Farmers
- NGOs (BRAC, Proshika and local NGOs and CBOs)
- DAE
- BARI
- BARC

- BRRI
- University Professors

Policy Options and Extension

Project outputs were summarised by Martin Adam and David Barton and presented to the second project workshop during July 2000. Policy options were explored during the workshop and the outcomes formed the basis of a leaflet designed for use by extension workers throughout Bangladesh. The leaflet will be printed in Bengali and English and 10,000 copies distributed to DAE, NGOs, Research Institutes and other interested organisations.

Project outputs will also form the basis of an extension video. The outline was designed and discussed with project staff at BAU and some video footage taken during the course of the project reviewed. Additional footage was suggested and a specialist video unit contracted to produce the film.

6. Contribution of Outputs

The impact of the project on the poor depends on whether the outputs are integrated into government policy. The underlying implications of the research findings are that:

1. The present trend towards PT-isation of cultivation operations does not generally disadvantage the rural poor. There are no significant effects on women or children. Therefore, if present price structures hold, the continuing expansion of the use of PTs for cultivation should be encouraged and efficient practices such as regular maintenance of machinery promoted.
2. However, there is some displacement of permanent farm labour. This displaced labour is presently finding alternative, and sometimes regarded as more desirable, occupations in the generally expanding wider economy of the country. As long as this trend continues, PT-isation may be regarded as having neutral or positive effects on the livelihoods of the poor. Changes in price structures for inputs and outputs should be monitored and analysed.
3. There exists potential for intensification of cattle production, in that cattle are becoming less in demand for draught purposes and are thus available for milk and meat production, but the reaction of cattle owners in this situation seems to have been to sideline or abandon involvement in the enterprise. Extension work could be turned to advice on how to best exploit this resource whose potential may be otherwise unrealised - or possibly allowed to become concentrated to the disbenefit of the poor.
4. As it has been found that the agronomic and energy balance impacts of PTs as used for cultivation are quite insignificant, further research into the potential impact of further PT-isation (or mechanisation in general) of post-harvest operations will provide relevant knowledge for possible future trends.

In the strict format of the original project logframe, the OVI at purpose level called for a 10% reduction of labour and power inputs per unit of production by 2005. The project has shown that the use of PTs for cultivation can improve labour productivity by 18-20% for the main rice crops (Table 7) and their use should therefore be encouraged by this criterion. However, overall farm energy use is not improved (Table 11). There is evidence that more significant reductions in labour can be attained with the introduction of mechanical hand

weeders – 25-30% (Islam & Sarker 2000) or herbicides (Ershadul Haque and Sarker 2000). It is likely, although the data has not been analysed for this factor, that significant improvements in overall farm energy balances can be achieved by the use of these innovations.

It is to be hoped that the dissemination pathways set out under Output 5 above will serve to bring the impact of the project findings to a wider audience.

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7. Communication materials

1. Books & book chapters,.

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2 (a) Journal articles published.

Bangladesh Power Options Project 2000. All papers presented in the July 2000 workshop - published in the *Journal of Agricultural Machinery and Mechanisation, (Bangladesh)* Volume 4, No. 1, October 2000 Special issue.

2 (b). Journal articles accepted but not yet published

Miah, T.H. 1999. Power Tillers versus Draught Animals : Choice of Technology for Cropland Cultivation in Bangladesh. Submitted to *Journal of Rural Development*, Bangladesh Academy for Rural Development, Comilla, Bangladesh.

2 (c). Journal articles planned

Adam, M., Barton, D.B. & Sarker, R.I. Cultivation power options in Bangladesh. For *Agricultural Systems*.

Adam, M., Barton, D.B. **& Sarker, R.I.** The impact of power tillers in smallholder farming systems in Bangladesh. For *Agricultural Mechanisation in Asia*.

3. Institutional reports

M.G. Adam & D. Barton 1999. Farm Power for Cultivation in Bangladesh: a Review of the Literature. *NRI Report No 6414.*

Islam, M.S. and Sarker R.I. 2000. The impact of the adoption of power tillers on landless labourers, sharecroppers and cattle producers in Bangladesh. Report of a PRA of six selected villages in Mymensingh and Tangail Districts. *NRI Report 6490.*

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4. Symposium, conference, workshop papers and posters

Bangladesh Agricultural University 1999. Participatory Rural Appraisal Report 1998. Submitted to the Natural Resources Institute (NRI) UK.

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Bangladesh Power Options Project 2000. Workshop on presentation of findings and recommendations, BAU Mymensingh 23rd. – 24th. July 2000. Volume 1: Papers presented to workshop; Volume 2 (to be published): Proceedings and summary of findings.

Alam, M.R., Sarker, R.I., Hossain, M.D. and Islam, M.S. (2000). Contribution of Livestock for Primary Cultivation on Small Farms in Bangladesh. Paper presented to the Asian-Australasian Association of Animal Production conference, 2-7 July, 2000, Sydney, Australia.

5. Newsletter articles

None.

6. Academic theses

Kamrul Kabir Bhuiyan, A.T.M. 1999. Energy input and output for the production of boro rice in Bangladesh. *A successful MS thesis submitted to the Department of Farm Power and Machinery, BAU for the degree of MS in Farm Power and Machinery in the semester July-December, 1999.*

Abdul Mannan, M. 2000. A study on livestock farming and the contribution in integrated crop-animal farming system. *A successful MS thesis submitted to the Department of Animal Science, BAU in partial fulfilment of the requirement for the degree of MS in Animal Science, June, 2000.*

Sultana, R. 2000. Thesis in preparation.

7. Extension-oriented leaflets, brochures and posters

Leaflet "Options for Farm Power for Cultivation on Small Farms". In English and Bengali.

8. Manuals and guidelines

None

9. Media presentations (videos, web sites, TV, radio, interviews etc)

Video "Impact of Power Tillers on Small Farmer Agriculture in Bangladesh", in preparation.

10. Reports and data records

(a) Internal project technical reports

Included in 3 and 4 above.

(b) Literature reviews

Included in 4 above.

(c) Scoping studies

None

11. Data sets (despatched electronically in zip file)

inputs1.xls	Input records from weekly survey for rabi / kharif 1 season
weekout.xls	Weekly survey field records collation for boro season
amandata.xls	Weekly survey field records collation for aman season
borostats.xls	Statistical tables on analysis of boro season results
blacksmith2.xls	Field records collation from survey of blacksmiths in Pakutia
boroen.xls	Records and analysis of energy parameters for boro season
enbals.xls	Energy balance records and analysis, boro season
daulatdata.xls	Village mechanisation data and analysis
DAEfigs.xls	National tractor and PT records by district, from Dept. of Agric. Extension

8. Project logframe

Hierarchy of Objectives	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
GOAL: Production of systems commodities increased through optimisation of inputs and outputs	By 2005 in a specified high potential production system in Bangladesh - Off-take increased by 15% - Management of inputs improved - System carrying capacity maintained or enhanced	- National production statistics - Reports of target institutions - Research programme reports - Evaluation of NRSP - Monitoring against baseline data	
PURPOSE: Strategies for the efficient management of labour and farm power (human, animal and/or mechanical) in Bangladesh developed and promoted.	By 2005, 10% reduction of labour and power inputs per unit of production	Adoption of strategies monitored against baseline statistics	- Extension services disseminate information - Farmers will be able to respond to information - Target institutions invest resources in uptake and application of research products - Enabling environment (policies, markets, incentives) for widespread adoption of strategies exists - Complementary research results on use of farm resources and animal feeds available

OUTPUTS: 1. Existing use of animal and mechanical power in small farms documented. 2. The impact of mechanised cultivation and draft animal power on: land and labour productivity, landless labour, yields, incomes and food security, and landlord/tenant relations quantified. 3. The impact of mechanised cultivation on cattle production, energy use and soil fertility analysed. 4. Policy options to optimise use of farm resources through soil fertility maintenance and increasing productivity of livestock and crops examined and presented. 5. Recommendations on farm power for extension services developed and disseminated through appropriate local and international channels.	1/2/3. Publication of literature review by 28 February 1999. Brief workshop proceedings within two months of the event. Results of on-farm investigation work of the implications of power tiller adoption described and published by mid 2000. 4 Policy options finalised and documented by October 2000. 5. Documents following discussion and agreement of policy options and extension messages at the end-of-project workshop	1. Literature review 2. Report on results of on-farm appraisals of socio-economic aspects of draught power use 3. Report on results of PRAs and surveys 4/5 Policy documents and workshop proceedings disseminated before November 2000 Two technical papers submitted to peer reviewed journals by February 2001	- Research and extension linkages exist to allow the necessary flows of information - Planners and extension services are willing to incorporate information and recommendations into extension and development policy - Results of the study are applicable throughout Bangladesh - Environmental and economic conditions are conducive to increases in agricultural production.

ACTIVITIES: 1.1 Literature review. 1.2 Develop methodology and select sites for fieldwork. 1.3 Identify participating farmers. 1.4 Establish links with other stakeholders. 2.1 PRAs and surveys to collect socio-economic data. 2.2 Data analysis. 2.3 Quantify impact of mechanised cultivation. 3.1 PRAs and surveys to collect technical information 3.2 Record changes in farming systems including cattle production, cropping systems 3.3 Construct models on the effects of the impact of mechanical cultivation on technical parameters 3.4 Analyse and present results. 4.1 Workshop to present results and examine policy options. 4.2 Draft policy options 5.1 Determine appropriate media for extension materials. 5.2 Develop materials with collaborating organisations.	NRI Staff £17,413 NRI overheads £24,514 Equipment £ 3,000 Overseas travel £8,800 Miscellaneous £40,189 TOTAL £93,916	1.Literature review and inception report 2. Quarterly reports of achievements 3. Quarterly reports of achievements 4. Policy documents and papers submitted to journals. 5. Extension materials; reports, workshop recommendations.	- Abnormal climatic variations do not occur during the project years. - Appropriate field staff recruited or found within collaborating institution (s). - Transport/costs met from the project budget and the collaborating institution(s) meet obligations.

9. Keywords

Draught, power, tillers, cultivation, mechanisation, cattle, smallholder, socio-economics, PRA, Bangladesh.

10. Annexes

As a separately bound volume:

1. **Miah, T.H. (1999)**. Power Tillers versus Draught Animals : Choice of Technology for Cropland Cultivation in Bangladesh. For *Journal of Rural Development*, Bangladesh Academy for Rural Development, Comilla, Bangladesh.

2. **Miah, T.H. (2000).** Impact of Power tiller utilisation on crop yield, income and employment of farmers in rural Bangladesh. From *Changing Rural Economy of Bangladesh* Ed. M.A. S. Mandol, Bangladesh Economic Association, July 2000. ISBN:984-31-0946-5.

3. **Eunus, M. (2000).** Soil fertility of Bangladesh and its management. *Bangladesh Power Options Project, supplementary paper.*

4. **Ershadul Haque, M. (2000).** Impact of Use of Power Tillers on Cropping Intensity, Timeliness and Turnaround Time. *Bangladesh Power Options Project, supplementary paper.*

5. **Miah, T.H. (2000).** Rising oil prices in Bangladesh: evidence of pushing up farmers risk in investing in power tillers. *Bangladesh Power Options Project, supplementary paper.*

6. **Alam, M.R., Sarker, R.I., Hossain, M.D. and Islam, M.S. (2000).** Contribution of Livestock for Primary Cultivation on Small Farms in Bangladesh. *Paper presented to the Asian-Australasian Association of Animal Production conference, 2-7 July, 2000, Sydney, Australia.*

7. **Kamrul Kabir Bhuiyan, A.T.M. (1999).** Energy input and output for the production of boro rice in Bangladesh. *A successful MS thesis submitted to the Department of Farm Power and Machinery, BAU for the degree of MS in Farm Power and Machinery in the semester July-December, 1999.*

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9. **Sultana, R. (2000).** Thesis in preparation.

10. Leaflet “Options for Farm Power for Cultivation on Small Farms”. In English and Bengali.

11. Video “Impact of Power Tillers on Small Farmer Agriculture in Bangladesh”, in preparation

Final Project Inventory

Item	Make and Model	Serial No.	Date received	Purchase price	Location	Disposal		
						To	Date	Authorised
Computer	Compro (ACS Computer Ltd, Singapore) Model: Pentium II MMX, 350 MHZ, Intel processor) with modem and accessories	981247	December 1998	Taka 90000.00 (approx. £Stg 1139)	Bangladesh Agricultural University			
Printer	EPSON LQ 670			Included in above	Bangladesh Agricultural University			
Computer	To follow	To follow	October 2000	Taka 77950.00 (approx. £Stg. 1022).	Bangladesh Agricultural University			