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COMMERCIALISATION OF AGRICULTURAL EQUIPMENT GENERATED BY R & D SYSTEM IN BANGLADESH

By

M.A. Jabbar

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Preface

Within the framework of the Technology and Employment Programme, this study is the last in a series on the role of national institutions in the commercialization of indigenous technologies. The set of empirical country case studies makes a balanced coverage of three important sub regions of Asia[1].

The major objectives of the study undertaken by Dr. M.A. Jabbar of the Department of Agricultural Economics of the Bangladesh Agricultural University are (a) to assess the farm equipment innovations generated by local R & D system and their commercialization; (b) to investigate sources of design of prototypes and appropriateness to farmer needs and local conditions; (c) to assess the collaborative linkages among R & D institutes, financial bodies, marketing agencies and farming community in the commercialization and dissemination of prototypes; and (d) to identify the form and mechanisms of and constraints to commercialization of prototypes.

All the major formal R & D institutions concerned with work on-farm equipment were closely studied. Five major manufacturing firms which make a significant contribution to adaptation and upgrading of farm equipment technology were also examined in depth. In addition, 30 farm equipment manufacturing firms and a sample of 100 farm households were included in the survey.

The most startling conclusion is that not a single prototype developed by the formal R & D institutions of Bangladesh has been commercialized. In contrast 20 prototypes developed by the private firms are being commercially manufactured. A number of factors which affect commercialization of prototypes generated by all R & D institutions in general and formal R & D bodies in particular, have been identified. The private manufacturing sector R & D has been more successful in commercializing their prototypes because they were more responsive to farmer needs and local conditions at the R & D stage. As a result market demand for the new product was not a constraint. The formal R & D system is handicapped by lack of institutionalized mechanisms for marketing and commercialization of their prototypes and the deprivation of the inventor in the formal R & D system of patency rights has acted as a disincentive to its commercialization. Conflicting government aid and commercial policies in the direct import of finished products have either made R & D efforts in certain agricultural equipment unprofitable or contributed to excess capacity in the manufacturing sector. The commercialization of prototypes generated by the formal R & D system is further hindered by lack of inter-disciplinary approaches and absence of coordination among R & D institutions (leading to duplication) and lack of collaborative linkages among R & D institutions, marketing agencies, financial institutions and the faming community.

[1] These are the Far-East (Indonesia, WP. 143), South Asia (Nepal, WP. 132) and the present case study country) and the Middle-East (Jordan WP. 150).

Contents

COMMERCIALISATION OF AGRICULTURAL EQUIPMENT GENERATED BY R & D SYSTEM IN BANGLADESH

INTRODUCTION

Historically, mechanization of agricultural production in the developed countries has passed through processes of transition between hand-tools, animal-drawn equipment and engine power, and through processes of improvement within each of the above categories. In the technical sense, each mechanization process (transition or improvement) aimed at increasing agricultural production through the release of labour constraints and/or performing tasks with improved timeliness too hard for manual labour. In the economic sense, each mechanization process aimed at realizing optimum returns to all resources having socio-economic costs in the context of the totality of social objectives which were different among different societies and nations (Green 1971 and 1976; Staut and Downing 1974). Consequently, there is no natural sequence or uniform evolutionary process of mechanization which may be followed as a blueprint or rule. Appropriate form of mechanization evolved in each society as an indigenous phenomenon manifesting outcome of the interaction of a multitude of forces within and outside the society (Jabbar 1982).

Agricultural production technology in Bangladesh is still predominantly muscle-powered. Almost entire primary and secondary tillage is done by draught animals. Weeding is primarily a hand-tool based operation. Harvesting is done by sickle or curved knife. Grains are threshed by both hand beating and animal treading. Post-harvest processing of other crops is also basically done by human labour. Bullock carts and human shoulder yokes are used for both on-farm and farm-to-market haulage. In recent years, use of improved elements, e.g. hand weeder, paddle thresher, sprayer has been slowly increasing, though the numbers of weeder, thresher and sprayer are not known. Irrigation and rice hulling are the only two operations where engine power has made significant head way. About 20 per cent of the total cropped area is now irrigated of which about 46 per cent is covered by engine-powered irrigation, i.e. deep tubewell, shallow tubewell, power pump. Small progress has also been made in tillage mechanization. Less than two per cent of the land is now cultivated by tractor and power tiller.

All traditional farm tools and equipment are manufactured by village carpenters, blacksmiths and small manufacturing firms. Improved manually-operated implements are also produced by small-scale manufacturing firms. Engine-powered equipment are mostly imported; a small amount is produced by large firms both in the public and private sectors.

An adequate and expanding power base is essential for increasing agricultural production which is particularly essential for a poor country like Bangladesh. Along with other things, farm equipment research in the country may contribute in this effort by

generating appropriate forms of farm equipment innovations so that (i) farmers may time their cropping operations more effectively so as to increase production; (ii) energy-use is economized; (iii) productivity of land, the most scarce resource, can be increased; (iv) without raising costs or reducing productivity, drudgery of labour of the farming community may be reduced; and (v) it does not lead to labour displacement.

The main objective of this paper is to outline the farm equipment research system in the country and then to examine the following:

1. To enumerate the number and kind of equipment designed by the R & D system and the number put to commercial use.
2. To find out how ideas for specific equipment designs originated and the extent to which generated prototypes are relevant to local situation and needs of the farmers.
3. To assess the extent of collaboration between R & D institutes, financial institutes and trading-marketing agencies at the technology generation stage.
4. To assess the impact of the prevailing structure of R & D system on the nature and extent of technology generation.
5. To identify the form and mechanism of commercialization of the prototypes.
6. To identify the nature and magnitude of the constraints (e.g. skills, workshop facilities, raw material, capital, market, institutional collaboration, government policy) on commercialization of prototypes.

The paper is divided into six sections. In the second section, the structure of farm equipment research and development system in the country has been described. It is seen that formal research organizations, manufacturing firms and individuals have involvement in farm equipment research. Sources of fund and manpower available for equipment research are also discussed in this section. Types of equipment already designed and currently being researched by various components of the research system, sources of design ideas for research and relevance of equipment research to farmer needs are discussed in the third section. Commercial production of various farm equipment designed by local R & D system and related problems are discussed in the fourth section. Government policies affecting farm equipment research and commercialization are discussed in the fifth section. Summary of the findings is presented in the final section.

STRUCTURE OF FARM EQUIPMENT RESEARCH AND DEVELOPMENT SYSTEM IN BANGLADESH

Until about 1800, technical development in developed world was in the hands of practical men, the carpenters and smiths in the villages. In the case of agriculture, the reign of the practical men continued until the introduction of internal combustion engine at the turn of this century. As time went on, science and technology slowly came closer. Gradually technical development came to be regarded as more of a result of patient, systematic institutionalized work than of accidental discovery by individuals. These processes have been distinguished by Babbage and Schumpeter as invention and innovation. However, both theoretical and empirical observations indicate that the relationship between

inventions and innovations particularly at the early stage of development is more varied and complicated than Babbage and Schumpeter had thought. Technical development is not homogeneous, for it comprises both the epoch-making changes produced by the great inventors and the infinitesimal changes effected by men whose names are not remembered (Heertje 1973). Even today, technical development may be triggered off by institutionalized research as well as by individuals working informally. Many scientists in formal institutions may be no more than routine workers while simple technicians may make significant contribution to technical development.

Components of farm equipment research system

In Bangladesh, farm equipment research system is composed mainly of a number of research organizations and equipment manufacturing firms. Carpenters, blacksmiths and innovative individuals may also be considered part of the system.

Among the research organizations, Bangladesh Agricultural Research Institute (BARI) at Joydebpur has the longest history of farm equipment research. BARI has grown out of the Bengal Department of Agriculture established in 1906. This department started introducing improved farm equipment in the 1930s. European design of mould board plough was one of the first equipment that they tried to introduce but if did not suit the small and weak animals of the province. The soil condition also appeared to be unsuitable for operating the European design and size. Technicians of the Department of Agriculture tried to scale down the size and adjust the design to local conditions but to this day mould board plough remains a subject of research.

In 1957 the provincial East Pakistan Department of Agricultural was divided into Directorate of Extension and Directorate of Research and Education. The Agriculture Institute established in 1938 for offering degree courses in agriculture was placed under the Directorate of Research and Education. An Agricultural Engineering Workshop was established under the Directorate of Research and Education with a view to promote farm equipment research and also to use it as a laboratory for practical teaching about farm machinery to undergraduate agriculture students of the Agriculture Institute. However, space, facilities and manpower in the workshop were not adequate to conduct any meaningful research. Except producing some slightly modified mould board plough units and Japanese hand weeders, the workshop virtually did nothing in the way of research (Haque 1975). In 1976, The Directorate of Agriculture (Research and Education) was transformed into Bangladesh Agricultural Research Institute (BARI) as an autonomous institution and its location was shifted from Dhaka city to Joydebpur. Bangladesh Agricultural Research Institute (BARI) is mainly responsible for research on all crops except rice, jute and sugarcane. The institute has a full-fledged Division of Agricultural Engineering to conduct research on farm equipment. Construction of physical facilities including workshop at the new location was completed by 1979 (BARC 1983).

The Bangladesh Agricultural University (BAU) was established in 1961 at Mymensingh as the highest seat of education and research in various agricultural

disciplines. The Faculty of Agricultural Engineering and Technology was established in 1964. Farm Power and Machinery is one of the four departments in the faculty. Teachers of this department are engaged in independent research alongside their teaching and supervision of graduate student research.

The Bangladesh Rice Research Institute (BRRI) was established in 1970 with major support from the International Rice Research Institute (IRRI), Manila. BRRI has a fullfledged Division of Agricultural Engineering for farm equipment and technology research.

The Bangladesh Jute Research Institute (BJRI), established in 1951 at Dhaka, has a small Agricultural Engineering Section with workshop facilities.

The Bangladesh Agricultural Research Council (BARC) established in 1973 is at the apex or the national agricultural research system. It is responsible for strengthening national agricultural research capability through planning and integration of resources. The Council has a Division of Agricultural Engineering and an Appropriate Agricultural Technology Cell (AATC). While the Division of AE is mainly responsible for funding and coordinating research, the AATC established in 1975 was expected to perform a bigger and more specific role in farm equipment research. The objectives of the cell cover development and promotion of labour-intensive and capital-saving machinery, tools and implement for agricultural production, manufacture of implements through greater utilization of local resources, development of appropriate drying, storage, processing and milling facilities to prevent post-harvest losses. It was also proposed that the AATC's scope of work would be expanded into such fields as animal husbandry, village-based industry, rural housing, etc., and at a later date the Cell would be upgraded to an autonomous Institute of Appropriate Agricultural Technology (BARC 1983).

The status of AATC within BARC has become vulnerable since 1979 when the Bangladesh University of Engineering and Technology (BUET) pre-empted the establishment of an Institute of Appropriate Technology (IAT). BARC also moved a parallel proposal but BUET got the approval of the Ministry of Agriculture primarily because at the time the Minister of Agriculture was an engineer. Later the Ministry of Planning also approved the IAT subject to the condition that the AATC of BARC had to be merged with IAT. The Planning Minister at that time was the former Minister of Agriculture. Concerned people and institutions are still in dispute about where the IAT should be located and who will control it. In the meantime neither AATC nor IAT is getting funds to do any useful wok. This is a classic example of how professional bias distort institution building and hinder progress in science and technology.

At least five manufacturing firms have been identified who have made significant improvement in equipment design and development. Over time such private efforts have helped to increase the level of technology and to adapt it to diverse agricultural conditions. These five firms are:

1. Comilla Cooperative Karkhana (CCK) established in 1962 at Comilla by a non-Bengali businessman to manufacture traditional and improved farm tools and equipment. After the independence of Bangladesh, the owner left the country and the workers of the firm formed a cooperative which now owns the firm.

2. New Light Inventor (NLI) established in 1962 by a family in Chittagong. In the beginning the owner himself has done valuable work in the improvement and development of equipment design. Later, he hired engineers and technicians to help him.

3. Ittafaq Industrial Corporation (IIC) established in the mid-1960s in Dhaka. The firm produces both agricultural and other equipment and has done some useful work in designing farm equipment.

4. North Bengal Agricultural Workshop (NBAW) established in 1981 in Rangpur by an agricultural engineering graduate who participated in the development of a pump design while working with a voluntary organization. He left the job to establish this firm where further improvement of the pump has been made.

5. Beauty Engineering Works (BEW) established in 1977 in Kushtia. The owner himself has developed equipment design.

The Bangladesh Steel and Engineering Corporation has a research division which is supposed to conduct research on various machinery development including farm machinery. The Machine Tools Factory, a component of this corporation with the largest equipment manufacturing capacity in the country also has engineers capable of doing useful research. Unfortunately neither the corporation nor the MTF has done any research.

A survey of traditional farm tools and equipment in the country for various farm operations shows that several designs/prototypes of the same equipment are available (Table1). Some prototypes of an equipment may have a high degree of similarity but others are quite different from one another. These different designs/ prototypes have been developed by village carpenters and blacksmiths to suit specific situations, e.g. design of a plough for predominantly sandy soil might be different from one for predominantly clay soil. Differences in design may also indicate different engineering sense of the carpenters and smiths who initially developed these designs. Although these designs have now stabilized through long time practice, one may come across the odd carpenter or blacksmith who is showing innovative capacity to improve existing equipment or to adapt improved equipment designed elsewhere in or outside the country.

Table1: Number of prototypes of different traditional equipment used in various farm Operations

Farm operation	Equipment used	Number of prototypes available
Land preparation	Plough	37
	Yoke	28
	Spade	8
	Ladder	3
	Mallet	13
Inter-culture	Hand hoe (Nirani)	46
	Rake	22
Irrigation	Swing Basket	14
	Hand Basket	2
	Done	11
Harvesting	Sickle	19
	Knife/Curved knife	14
Husking	Dheki	8
	Other	8

Source: BARC 1982.

Manpower and sources of funds of the research organizations

The present manpower engaged directly or indirectly in work relating to farm equipment in various organizations is shown in Table 2. It is to be noted that the figures in the table only show present and potential research capacity. Some of the engineers may be involved only in administrative work, others may devote only a part of their time in equipment research, still others may be doing only routine work performing only those tasks which their superiors ask them to do. Technicians and permanent service staff are shown to indicate the degree of assistance scientists may get in their work.

Scientists in formal research organizations conduct research mainly with resources available from the regular budget of the relevant organization. Individual scientists also get research grants for specific projects from different funding agencies, both local and foreign. The most important local source is the BARC, the University Grants Commission (only for BAU), Ministry of Agriculture, Rural Development and Planning. Notable foreign sources are DANIDA and IDRC. Private firms conduct research with their own funds.

Table 2: Manpower engaged in farm equipment research, 1985.

Institution/firm	Engineer	Technician	Service Staff	Total
Research Organisation				
BARI	17	12	28	57
BRRI	27	20	5	52
BJRI	5	5	2	12
BAU	12	30	10	52
BARC	8	-	-	8
IAT	1	-	3	4
Total	70	67	48	185
Manufacturing firms				
CCK	3	5	130	138
NLI	3	18	26	47
IIC	1	39	14	54
NBEW	1	2	7	10
BEW	1	6	12	19
Total	9	70	189	268
Grand total	79	137	237	453

Source: Field survey

EQUIPMENT DESIGNED BY THE R & D SYSTEM

Equipment designed

Equipment designs developed by different research organizations/firms are shown in Table 3. Most of the equipment is manually operated and adaptation/modification of foreign designs. Some of the designs which are claimed to be original are also not fully original in the sense that the basic principle of the design might have been taken from some other design. For example, the basic principle of the Chashi plough designed by BARI, Improved Country Plough designed by BAU and Mouldboard plough designed by CCK and NLI has been derived from the design of the European mouldboard design plough originally brought into India in the 1930s. The principle of the BRRI designed diaphragm pump has been derived from the diaphragm used by the blacksmiths for pumping air to increase heat of the open oven. In this case the principle has been applied to a different and more difficult job, thus can claim to be more original than in the case of the plough.

In addition to these, a workshop technician has developed the design of a manually-operated double axle pump; a foreign voluntary organization has developed a rower pump, a variant of the hand pump; a technician in Rangpur has developed the design of a bamboo tube well though a foreign voluntary agency now claims that it has developed the design; a farmer has developed a manually-operated shallow tube well/lift pump. More such innovative work might be identified if a countrywide search could be conducted. It is quite possible that some of this equipment could be standardized and made commercially viable. For example, a substantial number of low lift pumps distributed/sold by BADC in Tangail district became unusable because of the shortage of surface water. A workshop technician found the mechanism of adapting the engine of the lift pump for use with shallow tube well. Other workshops have quickly adapted the technique and these valuable machines have become useful. The technique might be quite simple but the point is that it has been devised by a local technician in response to a local problem.

Current equipment research

Current research on farm equipment in various organizations is summarized in Table 4. The objective of most of the research is modification and/or adaptation of designs already available. Some of the equipment under the research are at present commercially produced.

Sources of design and design ideas

Questions were asked as to which foreign designs were adapted/modified. BRRI has adapted mainly IRRI designed machines. IIC has also reported adapting IRRI designed power tiller and batch drier. In case of some equipment, the respondent could not properly specify the design but mentioned in general terms such as Japanese weeder and thresher. In most cases, the respondents could not specify the foreign design adapted/modified mainly because the research might have been conducted years ago by other scientists and the relevant literature was not immediately available.

Asked about the method of acquiring foreign designs, one or more of the following answers were giver: (1) from time to time government imported or received as aid/grant farm equipment for purposes of research, demonstration or sale among farmers. Samples of such equipment were collected. Similarly a locally designed equipment might be collected from the market for further modification; (2) design has been collected from scientific journals/documents; (3) preliminary idea of the design has been acquired during visit to farms/ workshops/ manufacturing firms in a foreign country; (4) expatriate experts worked with the organization/firm and his knowledge became the principal source of design information. It was observed that the same organization adopted different methods for acquiring designs of different equipment. Since most scientists who actually developed/adapted designs could not be personally contacted, specific method applied to collect design of specific equipment could not be gathered.

Table 3: Equipment design developed by different institutions/firms in different years (calendar years)

Name of operation and equipment	Name of organization/firm								
	BARI	BRRI	BAU	BJRI	NLI	CCK	IIC	NBAW	BEW
A. Tillage									
Mouldboard plough	-	-	-	-	62	62	-	-	-
Chashi plough (improved									-
improved country	1969	-	-	-	-	-	-	-	-
Plough)	-	-	1981	-	-	-	-	-	-
Power tiller	-	-	-	-	79a	80	-	-	-
Neck harness	-	-	79	-	-	-	-	-	-
B. Seeding/Sowing									
Seed drill (jute)	83a	-	-	46b	-	-	-	-	-
Seed drill	70a	77a	83a	-	73a	68a	-	-	-
Seed drill/wheat/soybean	70a	-	-	-	-	-	-	-	-
Seed treater	74c	-	-	-	-	-	-	-	-
Furrow opener		78	-	-	-	-	-	-	-
C. Weeding/Raking									
Hand hoe	65a	-	-	-	63a	60a	-	-	-
Hand weeder	65a	77a	-	-	-	62a	-	-	-
Jute weeder	80	-	-	46b	-	-	-	-	-
Hand sprayer	-	-	79a	-	-	-	-	-	-
Backpack sprayer	d	-	-	-	-	-	-	-	-
D. Irrigation									
Centrifugal pump	-	-	-	-	-	-	67	-	-
Diaphragm pump	-	77	-	-	-	-	-	-	-
Axial flow pump	-	78a	-	-	-	-	-	-	-
Reciprocating pump	79a	-	-	-	-	-	-	-	82
Vertical propeller pump		80a	-	-	-	-	-	-	-
Twin tredle pump	-	-	-	-	-	-	-	80	-
Cylinder pump	-	-	-	-	-	-	-	-	82
HS Diesel engine	-	-	-	-	-	-	83a	-	-
Hand pump	-	-	-	-	71a	72a	-	82	-
E.Post harvest									
Paddle thresher	1968a	-	78	-	75a	63a	-	-	-
Power cleaner	-	70a	83a	-	81a	-	-	-	-
Grain cleaner	-	-	-	-	-	-	81a	-	-
Winnower	65	-	-	-	-	72	-	-	-
Batch/rice drier	-	-	78a	-	-	79a	-	-	-
Corn sheller	83a	-	-	-	-	-	-	-	-
Hand ribboner	-	-	-	80	-	-	-	-	-
F. Other									
Grass cutter	-	-	-	-	64a	-	-	-	-
Straw cutter	-	-	-	-	78a	-	-	-	-
Electric brooder	-	-	78a	-	-	-	-	-	-
Tobacco curing unit	-	-	77	-	-	-	-	-	-
Storage bin	-	-	79a	-	-	-	-	-	-
Bullock cart	-	-	83a	-	-	-	-	-	-
Fertilizer applicator	-	c	-	-	-	-	-	-	-

a. Indicates that an existing foreign/local design has been modified/adapted.
b. BJRI's parent organization, Indian Jute Research Institute, evolved these equipment.
c. In collaboration with Chittagong Steel Mills.
d. In collaboration with two private firms
e. Not known

Source: field survey

Asked how the idea of adaptation/modification or development of a new design came, most respondents working in the formal research organizations said that the idea of adaptation was mostly derived from experience with existing designs at the research station. The idea of new design came mostly from the thought that improved farm implements were essential for agricultural development. All production problems had an engineering solution and farmers would be interested to use improved implements if suitable designs were available. The researchers hardly ever thought of going to the farmers to ask whether they wanted any improved implement to solve any particular problem. Equipment designs adapted/modified/developed at formal research stations have been tested at the stations but almost never in actual farm conditions.

Table 4: On-going research on equipment design in different institutions

Name of equipment	Year research began in various institutions						
	BARI	BRRI	BAU	BJRI	CCK	MBAW	BEW
Mouldboard plough	-	80	-	-	-	-	-
Power tiller	-	77	-	-	-	-	-
Minimum tillage	83	-	-	-	-	-	-
Multiple seed drill	-	80	-	-	-	-	-
Seed drill (jute)	81	-	-	-	-	-	-
Bullock drawn seed drill	83	-	-	-	-	-	-
Fertiliser applicator	-	84	-	-	-	-	-
Animal drawn pump	-	80	-	-	-	-	-
Vertical propeller pump	-	81	-	-	-	-	-
Jet pump (attachment to 2 cusec pump)	80	-	-	-	-	-	
4 cylinder pump	-	-	-	-		84	84
Power thresher	-	-	-	-	81	-	-
Paddle thresher (wheat)	80	80	-	-	79	-	-
Corn sheller	81	-	-	-	-	-	-
Mechanised ribboner	-	-	-	81	-	-	-
Rice/grain drier	82	-	-	-	80	-	-
Grain storage	82	-	-	-	-	-	-
Potato storage	79	-	-	-	-	-	-
Sugarcane crusher	-	-	-	-	78	-	-
Solar drier	-	-	83	-	-	-	-
Straw cutter	-	-	-	-	79	-	-
Biogas plant	79	-	-	-	-	-	-
Seed treater	-	-	-	-	75	-	-

Source: Field survey.

A completely different picture was found in the case of designs developed by equipment manufacturing firms. Since their main objective was commercial, they considered farmers' needs and problems as the primary basis of design development. Apart from on-farm tests, they got feedback from buyer-users and tried to make necessary adjustments.

If different prototypes/designs of the same equipment have been developed by different organizations, each organization was asked how its design differed from other or what were the special characteristics of its design. In most cases, the respondent could not answer because he was not familiar with other designs. In case of others, the nature of answer varied according to the type of equipment and whether the responden's own organization developed the design earlier or later than other organizations. However, the most common answers were that his own organisation's design was more efficient (do work faster and/or need less energy/effort to perform the task), more easy to handle and less costly. These claims could not, however, be verified.

Farm equipment research and farmer needs

For research to be done efficiently and for research results to be useful to the society, a kind of collaborative relationship should exist between the researcher and the client who uses research results. In view of the fact that equipment researchers in the formal research organizations have rarely, if at all, consulted farmers in identifying equipment research strategy, question may be asked as to the relevance of their research to the current and immediate future needs of the farmers. In order to answer this question, a small survey was conducted among 100 purposively selected farms who had experience in using improved farm equipment, e.g. weeder, thresher. The survey was conducted in Kotwali and Chandina Upazilas in Comilla district. Equipment manufacturers reported this area as one of the most important market for improved farm equipment.

Forty two per cent of the sample farms cultivated less than 2 acres, 33 per cent cultivated 2-2. 99 acres and 25 per cent cultivated more than 3 acres (Table 5). The sample farms, on average, cultivated 2.69 acres of land with 1.87 man-units of family labour and 1676 Taka worth of different farm equipment. They also hired equipment services from others worth Taka 2784 per farm during one year proceeding the survey.

All the farms produced one or more crop with DTW or STW irrigation though only 6 per cent farms own irrigation equipment (Table 6). Three farms own STW individually and three other farms own share of a STW. Sixty eight per cent farms hired tractor/ tiller services, none owned this equipment. All or nearly all farmers used thresher, weeder and sprayer but a smaller proportion of farms, particularly small farms, owned these equipment indicating that nonowners custom hired these equipment from owners. In fact some small farmers reported that they purchased thresher mainly for custom hiring, and thus using their labour more productively.

Table 5: Ownership of land, labour and major farm equipment by a sample of farms in Comilla, 1985.

Size of farm (acres)	No. of farms	Land cultivated (acres)	Total labour (man-units)	Agri. Labour (man-units)	Farm equipment (Taka[a])	
					Owned	Hired during the past year
2	43	1.20	1.43	1.07	1158	2189
2-2.99	33	2.43	2.15	1.06	1707	3062
3+	25	5.48	3.12	2.35	2503	3417
All	100	2.69	2.09	1.87	1676	2784

[a] Includes plough, rake, tractor/tiller, deep tubewell, shallow tubewell, weeder, sprayer, thresher, dheki, rice mill.

Source: Field survey, 1985.

Table 6: Proportion of sample of farms in Comilla owning and using selected farm equipment, 1985

Size of farm (acres)	No. of farms	Triller/tractor		DTW/STW		Weeder		Sprayer		Thresher	
		% used	% owned	% used	% owned	% used	% owned	% used	% owned	% used	% owned
2	43	52	-	93	50	100	57	86	10	100	2
2-2.99	33	76	-	100	85	100	85	85	21	100	6
3 +	25	84	-	1000	100	100	100	100	36	100	12
All	100	68	-	97	74	100	100	77	20	100	6

Source; Field survey, 1985.

The farmers were asked the reasons for using weeder, thresher and power tiller. Among the weeder users, 91 per cent mentioned weed control, 87 per cent mentioned softening of soil, 13 per cent better mixing of fertilizer as the reason for using weeder. Only 6 per cent mentioned quick weeding and labour saving, and 2 per cent mentioned better yield as the reason. Thus, it appears that breaking labour constraints may not yet be a major function of a weeder. Demand for weeder may depend more on the extent of line sowing, irrigation and fertilization.

Among thresher users, 87 per cent mentioned faster threshing thus saving labour as the reason. Fifty six per cent mentioned that most of the time boro (harvested in Spring) and aus paddy (harvested in mid-Summer) is to be threshed under wet condition, so animal treading is not suitable. Moreover, quality of HYV paddy is affected by animal treading, so they used thresher. Twenty six per cent of the users wanted to save their animals from hard work because threshing and puddling for transplanted Aman (rice harvested in late Autumn) had to be done at the same time. Twenty four per cent users said they had to use thresher because of inadequate draught animals, and 14 per cent said they used it because threshing could be done at any place of convenience. Thus, it appears that a diversity of reasons may create demand for thresher.

Tractor users gave the following reasons: quick preparation of more land (80%), deep plouphing possible (46%), less costly than animal (29%), bullock not good enough for hard soil (13%), replace draught animal (6%) and expected better yield)2%). Non-users of tiller gave the following reasons: tiller more costly than bullock (74%), have enough draught bullocks (71%), tiller not available at times of need (23%), fragmented land unsuitable for tiller (6%).

Mechanisation experiences of a number of East Asian countries show that tillage mechanization is preceded by first manual then engine power mechanisation of threshing, weeding and spraying operations (Duff and Kaiser 1984). Evidence from the limited sample survey presented above also indicate similar pattern for Bangladesh. Although there is a substantial shortage of draught power in Bangladesh, animal is expected to remain the main source of power for tillage for many more years. However, the present policy of privatization of irrigation equipment and, fertilizer and pesticide trade, may induce large farmers to increase self-cultivation of their land, thus demand for tiller may increase to some extent (Jabbar 1980; Jabbar and Green 1983; Gill 1984). Threshing and weeding are likely to be the most important operations to be mechanized quickly. Drying boro and aus paddy is a problem but mechanization of this operation may not become important unless a significant proportion of farms has become large-scale producers.

Previous and current equipment research agenda of the formal research organizations do not seem to adequately match the farmer circumstances, needs and priorities discussed above. It seems researchers are pursuing research in the field of their special interest or in the field where fund is easily available, without giving sufficient attention to their potential benefit for the farmers. In fact, researcher-client relationship has not been a subject of discussion, criticism or review because farmers derived almost no benefit from equipment research in the formal organizations. Almost none of the equipment so far designed/modified by these organizations is commercially produced (see below).

COMMERCIAL PRODUCTION OF EQUIPMENT GENERATED BY THE R & D SYSTEM

The application of an invention sometimes follows directly from a discovery, while in other cases there is a considerable time lag between the invention and its application. Diffusion and adoption may be hampered by commercial, social or technical factors.

Commercialisation of equipment designed by formal research organizations

Out of over 40 different types of equipment designs developed or modified/adapted by various components of the R& D system in Bangladesh, only 20 are currently commercially manufactured. All the manufactured prototypes have been developed and/or modified by private firms or individuals. None of the prototypes of any equipment designed and/or modified/adapted by the formal research organizations is commercially produced.

Although a patent law is in force in the country, no research organization (public institution) has patented its product designs and no initiative has been taken to make these equipment available to the farmers for whose benefit the research has apparently been conducted. However, these organizations occasionally get orders from various government agencies for a limited number of their equipment. If the number to be produced is small, they usually manufacture in their research workshop; if a substantial number is to be produced, usually a private manufacturing firm is contracted. For example, BJRI sometimes gets order for jute seed drill from the Directorate of Jute Production for its distribution among farmers participating in Intensive Jute Production Programme either free or at subsidized price. BJRI usually get them manufactured by some private firm. Since the seed drill is distributed throughout the country and neither the manufacturing firm nor BJRI is responsible for repair services, most of the seed drills become inoperative long before their actual life. Local blacksmiths and repair workshops may be capable of repairing but farmers generally discontinue line sowing after one or two breakdowns. Similar experiences have been reported by other organizations. About 50 units of BAU designed improved country plough were manufactured in the BAU workshop on orders from DANIDA for its rural development project area in Noakhali, from RDRS for distribution in Rangpur-Dinajpur and from GTZ for distribution in Tangail. Farmers were trained about its use and local blacksmiths were trained about its repair. Yet these ploughs became unusable after sometime and no new demand has been created among other farmers who saw it. The engineer who designed the plough also admitted that he did not do any evaluation of the working of the plough at the farm level.

The research organizations cannot and do not commercially manufacture equipment because their workshop facilities are limited and they also do not have any mechanism for marketing their products. Asked why private/public sector firms have not been contacted for manufacturing their design, some respondents replied that individual researchers considered their job finished with the development of design and publication of a research report. Finished design is an institutional property and promotion is an institutional responsibility but unfortunately research organizations are not performing their responsibilities properly in this respect. There are also practical difficulties. Demand for some equipment may not yet be large enough to attract manufacturers; some equipment may be costly to the farmers unless production costs ca be reduced or subsidy given on price. Since patent law is not properly enforced, some manufacturers try to copy other designs available in the market (for evidence see below) rather than coming to research organizations for better designs. It is apprehended that some firms have somehow acquired the design of certain equipment developed by some formal research

organization. Manufactures and potential manufacturers on the other hand complained that lack of approved designs and technology was a problem in manufacturing farm equipment (see below).

Commercialisation of equipment designed by private firms

About 30 firms located in Dhaka, Chittagong, Comilla, Noakhali, Bogra, Rangpur, Dinajpur, Kushtia and Faridpur are currently producing different prototypes of 20 different equipment designed or modified/adapted by the informal components of the R & D system in the country.

Detailed information about quantity produced, duration of production and sale price for some equipment are shown in Table 7. In addition to those mentioned in the table, one BADC owned-firm produced bamboo tubewell, one voluntary organization produced rower pump, 7 private firms produce about 3000 backpack and hand sprayers selling at Taka 100-500 per unit. About 3000 seed treater, 2000 hand rake, and 5000 incubators are also reportedly produced annually by some private firms whose detailed information were not available.

Of the 30 manufacturing firms only 4 private firms and a cooperative manufacture equipment of their own original design or modification of other slight modification (not necessarily improvement) or without. Since different firms operate in different areas and since demand is not yet very large, the question of patent or copyright violation is not generally raised. For example, out of 7 firms producing paddle thresher, Bengal and Samata were sales agents of CCK. Since there was no repair workshop in Noakhali area, they had to take the thresher to Comilla for repair, sometimes at their own expense, so that customer demand was not adversely affected. In response to customer demand for repair services and parts, they were encouraged to start a workshop. A few years later they started producing CCK designed threshers themselves. The prototype produced by Samata can be dismantled and the part required to be repaired can be taken to the repair workshop but for all other prototypes, the entire thresher has to be taken to the repair workshop.

Price differences of different prototypes of the same equipment partly reflect quality difference and partly reflect monopoly situation because each firm has more or less different market (geographical) areas under its control.

Size of business of manufacturing firms

The firms listed in Table 7 are reportedly working at 40-60 per cent capacity. Some firms produce non-farm equipment as well. Moreover, demand for farm equipment has a seasonal pattern. For example, most equipment are sold during boro season. Only paddle thresher sales has a second peak at the time of aman harvest. Therefore, sales of

Table 7: Production, sale and price of different farm equipment produced by different firms

Name of equipment and producer	Year first produced	Total units produced up to 1984[a]	Price per unit (Taka)[b]	
			First year	Last year
Mouldboard plough				
NLI	1962	1115	2.50	40
Seed drill				
CCK	1973	60	250	850
Weeder				
CCK	1966	3356	30	185
NLI	1967	1220	30	170
Hand hoe				
NLI	1963	1156	30	120
CCK	1966	1632	35	130
Radha Rani	1972	225	100	150
Janata	1983	22	-	150
Hand pump/3 cylinder Pump/Twin tredle pump				
NLI	1971	867	150	500
Jahed	1972	13200	600	800
Northern	1972	400	500	750
Faridpur	1973	3000	450	800
Vandari	1974	4500	400	650
BEW	1978	1100	450	750
Radha Rani	1980	40	500	600
CCK	1981	243	500	550
NBAW	1981	33029	160	185
Centrifugal pump				
IIC	1967	3300	3000	9000
Kibria	1972	1300	450	800
Amin	1972	1105	-	-
Reciprocating pump				
BEW	1982	238	-	600

Continued …/…

Name of equipment and producer	Year first produced	Total units produced up to 1984[a]	Price per unit (Taka)[b]	
			First year	Last year
Paddle thresher				
CCK	1970	950	500	1400
Bengal	1971	3150	500	1300
Radha Rani	1972	160	1000	1500
NLI	1975	698	500	1200
Northern	1980	130	-	1200
Samata	1981	210	1150	1350
Janata	1983	14	-	1500
Power thresher (wheat)				
Rahman	1977	-	8000	50000
Rice winnower				
CCK	1974	57	650	850
Oil expeller				
Amin	1969	585	-	-
Kibria	1972	950	800	1500
Arabian	1973	-	-	-
BEW	1974	150	800	1400
Vandari	1980	200	800	1000
Samata (coconut)	1982	10	-	14000
Sugarcane crusher				
Janata	1967	475	1000	4500
Faridpur	1968	600	1200	5000
Arabian	1973	-	-	-
Grass cutter	1973	384	150	300

a. Production did not take place every year during the specified period. Moreover, in the case of some equipment, the relevant firm could not provide production/sale data for every year.

b. Taka 27.56 = 1 US dollar.

- Not known.

Source: Field survey.

farm equipment cannot be taken as an indicator of the firm's size of business. For the same reason, value of land, building and machinery, and manpower also may not give proper indication of the size of farm equipment business. However, these may give some indication of the size of the firms (Table 8). The following should be noted in interpreting table 8: (1) some firms have unused land, so they will be able to expand building while others have fully utilized their land; (2) differences in value of building partly arise due to locational difference; (3) both building and machinery might have been undervalued. It is not clear how far differences in the value of machinery are due to differences in quantity and degree of sophistication; (4) most firms employ daily labour to evade minimum wage regulation and also to adjust to seasonal demand for equipment. Therefore, capital intensity of the firms could not be calculated.

Out of the 14 firms listed in Table 7, 8 firms did not borrow any investment capital. Only 6 firms borrowed an average of Taka 283,333 for purchasing machinery. This amount accounted for 68 per cent of their investment in machinery.

Table 8: Size of capital and manpower of selected farm equipment manufacturing firms

S1. No.	Land area	Building '000 Taka	Machinery '000 Taka	Engineer	Technician	Permanent labour
1	0.72	700	1200	3	5	130
2	-	600	1200	0	8	4
3	0.32	400	1000	0	6	9
4	4.00	-	700	4	22	52
5	0.40	300	400	1	39	14
6	0.80	120	350	4	9	11
7	1.00	-	300	1	6	12
8	-	200	300	3	2	5
9	0.36	-	300	1	5	13
10	7.38[a]	-	200	1	2	7
11	0.40	80	200	1	4	19
12	0.70	-	200	1	5	16
13	0.25	60	150	0	4	18
14	0.52	100	-	3	18	26
Average	0.86[b]	284[b]	500[b]	1.7	9.6	21.3

a. Large part of the land is now used for farming, excluded from average.
b. Calculated taking only positive values.

Source: Field survey.

Asked about problems in expanding the manufacture/manufacturing capacity of farm equipment, 22 manufacturing firms responded giving different combination of the following problems: shortage and high price of raw material (73%)[5], inadequate market (73%), insufficient working capital (64%),[6] irregular supply of electricity (32%), lack of approved design and technology (18%), lack of appropriate machinery (18%), lack of skilled manpower (14%), and lack of patronage (14%).[7]

Method of sale and related problems

Detailed data on method of sale were available from 18 firms manufacturing different equipment designed/modified by the national R & D system. Channels used by these firms for selling their products are as follows:

Marketing channel	No. of firms
1. Firm – user	12
2. Firm – user/firm – retailer – user	3
3. Firm – govt. agency/voluntary agency – user	2
4. Firm – wholesaler – retailer – user/ Firm – retailer – user/ Firm – user	1

All but two firms said that they did not face much problem in marketing because they produced only as much as they would be able to sell. Sometimes they produced certain quantities of specific equipment on definite orders. Moreover, they operated in specific geographical areas so that rough assessment of possible demand could be made. One big firm selling mostly directly to users mentioned that most users came directly to the firm for repair services, consequently a significant portion of time and skill had to be diverted to this job from production. Attempt to find wholesaler did not work so far because of the uncertainty of the business. Another firm selling an equipment to a government agency said that the relevant agency being a monopoly buyer, other competing manufacturing firms sometimes managed to get orders although their products were of much lower quality. The firm suggested that this problem could be solved by allowing direct sale to users.

GOVERNMENT POLICY, FARM EQUIPMENT RESEARCH AND COMMERCIALISATION

Generation of appropriate agricultural technology in a country depends more on local capacity for invention than on external forces. Communication and cooperation among scientists and engineers knowledgeable about local agricultural situation, resources and practices on the one hand and farmers on the other, is also required for successful evolution of appropriate technology[8]. In Bangladesh, little planning has been done to rationalize technology research in general and mechanization research in

particular. An ad hoc approach has been taken mainly based on the availability of foreign aid. Proper attention has not been given to the economic and technological needs of the farmers. Engineers and economists rarely, if at all, discuss before or during the design experiment stage or even in the case of ex-post evaluation of on-farm performance.

In creating research capacity, specific crop oriented research institutions have been built with donor funding, thus along with other things engineering research capacity has been multiplied. But there is little coordination among the research institutions and the scientists. Even scientists working in close proximity rarely communicate with each other. Consequently, similar work is duplicated as described earlier. In the absence of national level planning and in the absence of researcher-farmer interaction for identification of technological needs, individual researchers pursue research according to their specialized skill and interest. BARC's role as national research coordinator has so far proved to be ineffective. The controversy about the status of the Appropriate Agricultural Technology Cell at BARC and the Institute of Appropriate Technology at BUET has further delayed and hampered the process of coordination of farm equipment research and commercialization.

Foreign aid and trade related policies are also responsible for non-commercialisation of locally designed/modified equipment. Irrigation development has been the main strategy for achieving self-sufficiency in foodgrain and economic development during the last 20 years. During this period, appropriate irrigation technology for the country's situation has remained a debatable issue; everything from bamboo tubewell to deep tubewell have been suggested as appropriate depending on who has done the analysis at what time for what purpose. The ultimate result is that many different types of irrigation equipment are now operating in the country but the majority of the engine-powered equipment have been imported with external aid/assistance. While engine-powered irrigation equipment is still being imported every year with foreign aid , equipment researchers in the national research organizations are researching on different types of manually-operated irrigation equipment. Basic and applied research on engine-powered irrigation equipment design within the country has never been encouraged.

Similar is the case with power tillers. BRRI undertook a programme for modification/adaptation of IRRI designed power tillers (and also power threshers) and a collaborative agreement was made with Bangladesh Machine Tools Factory, the largest machinery manufacturing firm in the country, for commercialization of the improved design. About 300 modified tillers were reportedly manufactured but most of them still remained unsold. On the other hand, power tillers are being imported from time to time with foreign aid. In 1980, the Head of the Government, while visiting the factory, announced that power tillers would no longer be imported but a few months later, Bangladesh Krishi Bank signed a contract with the Asian Development Bank for importing about 500 power tillers. As a result of all these, BRRI's power tiller research has made little progress.

The objective of patent law is to grant inventors exclusive right for exploiting their inventions on a commercial basis for a certain number of years. Thus, patent law is expected to stimulate inventions and propagation of knowledge, and bring more scarce resources into research. But scientists working in formal research organizations in Bangladesh are not legally allowed patent rights of their inventions. This right rests with the relevant organization. Thus, scientists have little incentive to do more than routine work. They also have little incentive to negotiate with commercial equipment manufacturers on behalf of their organization for commercial manufacture of their invented equipment. The organizations are also not taking any initiative to negotiate with manufacturers and financiers to commercialise products which scientists of these organization have designed/developed. The Appropriate Technology Cell at BARC was expected to perform this negotiating role but, as mentioned above, its own status has been in question for some years now.

Substantial local manufacturing capacity of farm equipment has been created with foreign aid/assistance but that capacity cannot be utilized because of foreign aid based development strategy. For example, the entire annual demand for engine-powered irrigation equipment can be met by local manufacturers in both private and public sectors. But they produce only 20-30 per cent of annual demand because of shortage of raw materials and working capital. Aid donors are more interested to sell their pumps and tubewells rather than raw materials for the local industry. Since vested interests in the government may also be more interested in contracting aid, they are less prepared to make adjustment in the country's budget and release sufficient working capital to the industries. Such adjustment can be easily made by reducing unproductive or less productive expenditures. The long-term consequences of such short-term adjustment for achieving national self-reliance might be very great indeed.

Trade and taxation policies of successive governments have also adversely affected commercial production of locally designed equipment. A general characteristic of the trade policy is to import equipment which can be locally manufactured. Moreover, tax rates on imported raw material and the imported equipment may be such that the production cost of the locally manufactured equipment may become higher than the imported one. Licence for importing raw material may also be unduly controlled. For example, after the 1985-86 annual budget was declared, sprayer manufacturers complained that they had more than enough manufacturing capacity to meet the entire annual demand for sprayers yet the government had decided to import sprayers and charge higher tax rate on raw materials, thus putting local manufacturers at a further disadvantage. Similar complaints are frequently heard in other industries/sectors of the economy.

SUMMARY

The farm equipment research system in Bangladesh consists of a number of formal research organizations, a small number of farm equipment manufacturing firms, some voluntary agencies, and innovative individuals. Seventy engineers and 67

technicians are currently working in farm equipment research divisions or various formal research organizations. Nine engineers and 70 technicians work in five firms involved in equipment research. Since some of these people do not spend full time in research, the number does not fully represent the actual research capacity. In formal research organizations, research is conducted with regular budget funds of the organizations and also grants received by individual researchers on specific projects.

About 40 different types of equipment design have been developed. Most of these are manually operated and adaptation/modification of foreign designs. Original foreign designs have been acquired from local markets, from journals/reports, during personal visits to foreign countries, from expatriates working in the country. The idea of an original design or of a modified design came to researchers in the formal research organizations from experiences with existing equipment at the research station and from the thought that improved farm implements were essential for agricultural development. It was assumed that all production problems had an engineering solution and farmers were expected to use improved implements if suitable designs were available. On the other hand, researchers in the private manufacturing firms considered actual needs and problems of the farmers as the basis of design development because they wanted to devise equipment which they would be able to sell immediately.

A survey of 100 farms using different improved farm implements revealed that different implements were used for different reasons e.g. relax labour constraints and animal power constraints, reduce cost, improve soil quality etc. The ownership and use pattern of implements indicate that thresher, weeder and sprayer are the most important equipment which farmers are likely to use extensively in the near future. Demand for power tillers will increase at a faster rate than before due to animal-power shortage on the one hand and increased self-cultivation of land by private tubewell owners on the other. However, animal will remain the dominant source of power for tillage for a long time. Demand for driers may not become important unless a significant proportion of farms has become large-scale producers.

The farmer's circumstances, needs and priorities were not adequately reflected in the past, neither are they reflected in the present research agenda of the formal research organizations. It seems researchers are pursuing research in the field of their special interest or in the field where funds are easily available. Communication and exchange of ideas among researchers and among institutions was found to be very poor. Funding agencies have also failed to improve the situation. Consequently some research has been unnecessarily duplicated.

Out of about 40 different pieces of equipment designed by various components of the R & D system, only 20 prototypes developed by the private firms are commercially manufactured. None of the prototypes developed by formal research organizations is commercially manufactured. Sometimes small quantities are manufactured in the research workshop on specific orders from government organizations. The designs have also not been patented. The inventor is not entitled to patent right, so he does not take any initiative. The relevant organizations also do not take any initiative to get the

prototypes manufactured by commercial manufacturers. The Appropriate Agricultural Technology Cell at the Bangladesh Agricultural Research Council was expected to perform, among other things, the role of negotiator between research organizations and commercial manufacturers. Unfortunately, the status of AATC itself has become doubtful since 1979 when an Institute of Appropriate Technology was established at the Bangladesh University of Engineering and Technology. These two organizations are still in dispute about where the IAT should be located, who will fund and control it. This is an example of how professional bias and rivalry hinder institution building and progress in science and technology.

About 30 firms are currently producing 20 different prototypes of farm equipment developed by local R & D system. Five of these firms produce equipment of their own design, others copy prototypes available in the market. The question of patent or copyright is not generally raised because slight change may be made from the original prototype. Moreover, these firms serve different market areas, so face little competition. Most of the manufacturing firms also produce non-farm equipment. The majority of them invested their own capital, some borrowed from bank for purchasing machinery. Most of the farm equipment manufacturers sell their products directly to the users. Some firms sell partly through retailers, others sell through government agencies or voluntary organizations. Shortage and high price of raw materials, inadequate demand, insufficient working capital, irregular supply of electricity and lack of approved design and production technology have been mentioned as major problems in expanding the manufacture/manufacturing capacity of farm equipment.

A number of government policy measures including foreign aid-based development strategy, the establishment of mono-crop based research organization, import of farm equipment and imposition of higher tax on certain raw materials, non-enforcement of the patent law and deprivation of the inventor working in formal research organization from patent right have adversely affected farm equipment research and commercialization. Substantial capacity for manufacturing farm equipment has been built with foreign assistance but the major part of that capacity remains under-utilised mainly because of the shortage of raw materials and working capital. It is easier to get foreign assistance for purchasing farm machinery, e.g. pumps, tubewells, tractors, power tillers, than to purchase raw materials for manufacturing machinery at home. The problem can be substantially solved by making budgetary adjustments and adopting appropriate policies to support procurement of raw materials rather than import finished products but this does not happen mainly because of aid-biased policies of the government which involves acceptance of tied foreign aid.

Notes

1. Duff (1980) mentioned that international transfer of technology may take place through transfer of material, transfer of knowledge and transfer of capacity. Any of these changes may occur through multinationals, national agencies, private firms, and international agencies. It appears that researches in Bangladesh, have acquired ideas of equipment designs from all the sources.

2. In a study of power tiller owners in Munshigonj and Mymemsingh, Jabbar et al (1983) found that some tiller owners in Munshigonj purchased tiller mainly for custom hiring.

3. Summarising extensive investigations of a number of researchers about technology diffusion in the manufacturing sectors of the developed countries, Heertje (1973) concluded that inventions financed by the public sector are applied after a shorter interval than those financed by the private sector, though the average time-lag seems to be decreasing over time.

4. An evaluation is underway four years after the ploughs were distributed. The evaluation itself has been initiated at the advice of an economist.

5. In 1975, CCK Chairman reported that between 1970 and 1974, prices of raw materials for farm equipment manufacture increased by, on average, 560% while prices of farm equipment increased by, on average, 282%. Further price increase would reduce the size of the market (Bose, 1975).

6. The Bangladesh Krishi Bank has provision of short, medium and long-term credit for establishment of implement manufacturing firm and also for working capital for the firm (Rahim, 1985). Sonali Bank also has similar provision. Yet insufficiency of working capital apparently remains a problem, the reason for which could not be adequately clarified by the manufacturing firms or the banks.

7. A survey conducted in 1980 revealed that 20 private firms were manufacturing various types of farm equipment and 12 others had facilities for such manufacture. Asked about problems in manufacturing farm equipment, the following answers were given: inadequate market (75%), shortage of raw material (72%), insufficient working capital (69%), lack of approved design and technology (31%), lack of appropriate machinery (22%), irregular electricity (25%), lack of patronage (22%), and lack of skilled manpower (9%), (BARC 1980).

8. In order to design equipment that serves farmer needs, that is within the purchasing capacity of the farmers and that can be repaired by local blacksmiths and workshops, IRRI has adopted an interdisciplinary approach. Engineers,

economists and other scientists communicate right from the primary idea of any equipment through to commercial production. As a result, any equipment which may appear inappropriate for the particular time, purpose or situation, is screened out before scarce resources have been wasted (Nichols, 1975).

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