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RECENT DEVELOPMENTS IN MECHANIZED CULTIVATION:

EMERGING ISSUES IN THE AGRICULTURE OF BANGLADESH

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EXECUTIVE SUMMARY

The agriculture that we witness in the contemporary developed world has reached this stage of high modernity over decades of development in mechanical, biological and chemical technology. Asian developing countries, including Bangladesh, have experienced only limited progress in advancing their agriculture along the technological path, mainly through the bio-chemical innovations involving seeds and fertilizers. However, irrigation development that provides a basic foundation for seed fertilizer technology portends a substantial degree of mechanization. Mechanization of cultivation for clearing, plowing and leveling of cropland has spread rather thinly in Asia, perhaps because of a factor endowment dominated by abundance of labor and scarcity of land. But careful analysis of countries like Taiwan, Korea, Thailand and Malaysia demonstrate that highly productive agriculture cannot be attained without application of modern mechanical technology to complement seed-fertilizer technology. Even, the success of both the Indian and Pakistan Punjab in the development of a progressive agriculture tells us this fact of the re-enforcing role of mechanized cultivation.

Deepening of seed-fertilizer technology and expansion of commercialization have begun to bear upon the spread of mechanized cultivation in Bangladesh as in many other developing countries of Asia. The production process in crop agriculture entails a number of strenuous field operations. The effectiveness of these operations determines the extent of production through changes in both yield and cropping intensity. This paper focuses on mechanized cultivation, particularly, power tillers and tractor cultivation.

It is apparent that labor requirements for rice cultivation are highest in the land preparation and planting phase of the production cycle. This phase spreads over about a month. The second phase of inter-culture operation spreads over about two months and in this phase the labor requirement is relatively thin. In the final phase of the production cycle - the harvesting season of rice that extends over a period of about a month - the labor requirement is again pretty high.

The objective of this paper is to provoke fellow researchers and invite them to undertake new studies on various issues of mechanization in crop production of Bangladesh. As we will see later, mechanization has assumed a heightened trend in recent years and is still an unexplored area in policy research. The paper therefore, sheds little light on empirical findings, but possibly generates enough heat to induce colleagues in new studies on mechanization.

HISTORICAL PERSPECTIVE AND THE CURRENT STATE OF MECHANIZATION

Unlike irrigation-based seed-fertilizer technology, progression of mechanized cultivation has occurred with little public intervention and promotion of technology. The first public initiative was undertaken through a scheme of mechanized cultivation in the mid-sixties, mostly for the Haor areas of Bangladesh. In those days most of the land used to remain fallow during the dry season because of a thicket of sturdy weeds that could not easily be broken by plough. The tractor was instrumental in working these lands under boro crop, of course, under irrigation by means of a low-lift pump (East Pakistan, EPADC, the mechanized cultivation and power pump irrigation scheme, 1966). However, this scheme could not make a significant and sustainable impact on mechanized cultivation. The second public initiative in mechanized cultivation was launched in 1965 through a project called the Pak-Japan Cooperative Scheme for introduction of tractors and power tillers in the then East Pakistan. This program was able to make a small but significant success in getting the technology known among a small proportion of the farm population, particularly in the potato growing areas. The Agricultural Censuses of 1977 and 1983-84 provide some rudimentary statistics demonstrating that only about two-tenths of a percent of cropped land was cultivated by tractors and power tillers in 1977 as well as in 1983/84.

The current state of mechanization is best reflected in the report of the 1996 Agricultural Census. The census data demonstrates dramatic progress in the use of power tillers and small tractors in Bangladesh. On average, about 28 percent of cultivated land was plowed with power tillers and tractors in 1996. It seems that progress in the application of

power tillers/tractors in Bangladesh was rapid in the 1990s, after the liberalization of agricultural input markets, particularly the liberalization of markets for agricultural machinery in 1988. However, the spread of mechanization is quite uneven among various districts. Fifteen districts use power tillers on less than 10 percent of cultivated lands and another 10 districts use power tillers to cover only 10 to 20 percent of cultivated land, while 26 of the 54 districts extensively use power tillers on more than 30 percent of their land. The use of power tillers is common among all size-groups of farmers. However, large and medium farms are found to use power tillers in proportionately greater extent than small farmers.

Regression analysis of district-level data from the 1996 Agricultural Census indicates that labor supply, propensity of irrigation, availability of work animals and cropping intensity are all correlated with the rate of adoption of power tillers. Similarly, regression using cropping intensity as the left-hand-side variable indicates that a 10 percent increase in power tiller cultivation results in a 1.3 percent increase in cropping intensity.

ORGANIZATIONS FOR POWER TILLERS

There are few farmers who can own and operate power tillers for cultivating only their own land. The holding size of most farmers would dictate that a farmer would own a power tiller and sell its services to other farmers, as is commonly the case with shallow tubewells. Who takes the initiative, how is the purchase of a power tiller financed and what is the pricing mechanism involved in selling the services to other farmers? This information is currently not known precisely. It is also not known whether a monopolistic or a competitive market mechanisms is involved in the provision of services. This information is necessary not only to find efficient methods of organizing services but also for monitoring whether the new technology is influencing changes in the traditional land rental market or polarizing the distribution of farm sizes in rural Bangladesh.

IMPACTS ON PRODUCTION

The production impact of power tillers is expected to occur through a) increased cropping intensity, b) increased yields and c) cost- savings in plowing. Analysis tends to indicate that increased cropping intensity is perhaps the most significant source of a positive impact. However, this conclusion is based on cross-sectional data that might not be a true reflection of impact under a dynamic situation. To capture the dynamic effects it would be necessary to ask farmers about these dynamic effects through field surveys.

Experiments conducted at the Rice Research Institute indicate that the impact of better tillage on rice yield varies by nature of soil structure. Areas with hard soils get a better impact from tillage than in sandy or loamy soils. In general, the yield impact is small. However, power tiller cultivation might allow farmers to incorporate field stubbles and other vegetations into the soil mass, thus improving the organic matter content of the soil. Bangladesh soils, generally very deficient in organic matter, may derive a substantial benefit in this regard from mechanized cultivation.

The cost-saving effect of replacing bullock power with power tillers could, however, be very substantial. On the basis of some rudimentary information on prices of power tillers and bullocks, maintenance costs, operation costs and life, an estimate of comparative costs of land preparation between bullock plowing and power tiller plowing has been made. Non-farm uses of power tillers have been ignored but could be substantial.

Even though the estimates are crude, it seems that power tillers cost about 50 percent less than bullock cultivation. Moreover, the implicit cost of risk involved in maintaining bullocks (e.g. sudden death), if included, would increase further the cost of plowing by bullocks. This cost-savings could therefore be a powerful driving force in switching from bullock power to power tiller. It will bear implication for competitive advantage and total factor productivity of crops.

IMPACTS ON EMPLOYMENT

The employment impact of mechanized cultivation has always been a fashionable subject arousing debates and controversies. It is probably not questionable that the substitution effect of mechanization generates a negative impact on employment. But the output impact that gets generated through, as for example, increased cropping intensity, is positive and may surpass the substitution effect. This theoretical proposition often warrants to be analysed with careful consideration of seasonal and spatial segmentation of input markets that might render straightforward aggregation of market parameters implausible since the nature of labor requirements vary across stages of a crop-cycle.

So, analysis of seasonal wage rates and seasonal labor requirements for all crops combined is important. When labor requirement exceeds labor supply, as in the land preparation and harvesting phases, the wage rate ought to go up to equilibrate the supply of and demand for labor during that season. Such a model would then be able to predict what impact a labor substituting mechanical technology would bear upon the employment situation in agriculture. It is hoped that the research agenda in the follow-on project of IFPRI will include this aspect.

CONCLUDING OBSERVATIONS

The evolution of the agriculture of Bangladesh into a modern sector comparable to the agricultures of east Asian developed countries can not be conceived without a thriving role of mechanical technology. The emerging picture of the adoption of power tillers and tractors seems to be a beginning of modernity. How the process can be accelerated without any serious negative impact on employment and poverty should attract professional attention. The progress that has been achieved so far is not the result of any significant public intervention. Market forces seem to have driven the process. Therefore, it may logically be argued that studies on mechanization are not necessary. Such a conclusion would be wrong and counterproductive. Policy makers of Bangladesh ought to know what social implications

are involved in the market-driven process of mechanization. The government would then be in a position to adopt right policies as well as explain the rationales to donors.

The reduction of cattle population for draft purposes may bear a more far-reaching implication for the crop-sector, particularly in respect to total factor productivity and competitive advantage. Therefore, these aspects of mechanization warrant serious investigation.

1. INTRODUCTION

The agriculture that we witness in the contemporary developed world has reached this stage of high modernity over decades of development in mechanical, biological and chemical technology. Asian developing countries, including Bangladesh, have experienced only limited progress in advancing their agriculture on a technological path, mainly through the bio-chemical innovations involving seeds and fertilizers. However, irrigation development that provides a basic foundation for seed fertilizer technology portends a substantial degree of mechanization. Mechanization of cultivation for the clearing, plowing and leveling of cropland had spread rather thinly in Asia, perhaps, because of a factor endowment dominated by the abundance of labor and scarcity of land. But a careful analysis of countries like Taiwan, Korea, Thailand and Malaysia demonstrates that highly productive agriculture can not be attained without the application of modern mechanical technology to complement seed-fertilizer technology. Even, the success of both the Indian and Pakistan Punjab, in the development of a progressive agriculture tells us this fact of the re-enforcing role of mechanized cultivation.

Deepening of seed-fertilizer technology and expansion of commercialization have began to bear upon the spread of mechanized cultivation in Bangladesh as in many other developing countries of Asia. The production process in crop agriculture entails a number of strenuous field operations. The effectiveness of these operations determines the extent of production through changes in both yield and cropping intensity. A brief catalogue of these field operations is presented in Table 1, in order to enhance the understanding of the readers of the specific meaning of mechanized cultivation. Mechanized cultivation may mean the application of machine power in any of the operations listed in the table. However, in the context of this paper, the use of machine power in land preparation and plowing operations, is termed as mechanized cultivation.

Table 1 — Steps of Field Operations in Rice Cultivation Mymensingh Area, Bangladesh

	Field Operations	Labor Requirement (Person days/acre)		
		Family Labor	Hired Labor	Total
A.	**Land Preparation + Planting**	**13.4**	**15.7**	**29.1**
	Cleaning of Land	1.0	0.1	1.1
	Plowing	4.6	3.8	8.4
	Laddering	0.1	0	0.1
	Sowing	0.1	0	0.1
	Seed bed Preparation	1.0	0	1.0
	Pulling Seedlings	1.1	0.7	1.8
	Transplantation	5.5	11.1	16.6
B.	**Intercultural Operation**	**6.4**	**6.2**	**12.6**
	Fertilizing	0.6	0.2	0.8
	Weeding	5.3	5.9	11.2
	Irrigating	0.4	0.1	0.5
	Pesticides Application	0.1	0	0.1
C.	**Harvest**	**7.9**	**9.2**	**19.1**
	Harvesting	5.0	10.2	15.2
	Carrying	0.7	1.0	1.7
	Threshing/Drying	2.2	0	2.2
	Total Labor	**27.7**	**33.1**	**60.8**

Source: IFPRI, 1998 Survey under Micro-Nutrient Study

More specifically, the subject of power tiller and tractor cultivation is our primary focus here.

It is apparent that the labor requirement for rice cultivation is highest in the land preparation and planting phase of the production cycle. This phase spreads over about a month. The second phase of inter-culture operation spreads over about two months and in this phase labor requirement is relatively thin. In the final phase of the production cycle, during the harvesting season of rice, which extends over a period of about a month, the labor requirement is again pretty high.

This introductory statement on the importance of various operations in the production cycle, particularly from the angle of labor requirement, is critical for an understanding of the problems perceived by farmers in their decisions on mechanization. Another factor that exerts influence of a hidden nature in the decision on mechanization is the arduousness of specific operations. The degree of arduousness may be defined as the amount of relative

calorie expenditure per unit of time in completing a farm operation. The arduousness of operations in the land preparation and planting phase is perhaps the most severe compared to other operations. These two factors are often missed in economic analyses of mechanization that usually focus on relative prices of factors of production and output.

The objective of this paper is to provoke fellow researchers and invite them to undertake new studies on various issues of mechanization in crop production in Bangladesh. As we will see later, mechanization has assumed a heightened trend in recent years and is still an unexplored area in policy research. The paper therefore, sheds little light on empirical findings, but possibly generates enough heat to induce colleagues to conduct new studies on mechanization. More specifically, the paper raises the following questions in agricultural mechanization in Bangladesh.

1. Has mechanization really assumed a heightened pace in recent years? If so which factors have underpinned this trend?
2. How is the provision of mechanical services organized among farmers?
3. What is the aggregate impact of mechanization on production?
4. What is the impact of mechanization on employment in agriculture?
5. Is mechanization likely to accelerate the process of polarization in holding size in agriculture?

It is hoped that enough new studies on these questions would be forth-coming so that the progress of mechanical technology in the agriculture of Bangladesh is not stalled because of likely controversial propositions surrounding mechanization.

2. HISTORICAL PERSPECTIVE AND THE CURRENT STATE OF MECHANIZATION

Unlike irrigation-based seed-fertilizer technology, progression of mechanized cultivation has occurred with little public intervention or promotion of technology. The first public initiative was undertaken through a scheme of mechanized cultivation in the mid-sixties, mostly for Haor areas of Bangladesh. In those days, most of the land used to remain fallow during the dry season because of thickets of sturdy weeds that could not easily be broken by plough. Tractors were instrumental in working these lands under *boro* crop, of course, under irrigation by means of low-lift pumps (East Pakistan, EPADC, the mechanized cultivation and power pump irrigation scheme, 1966). However, this scheme could not make a significant or sustainable impact on mechanized cultivation. The second public initiative in mechanized cultivation was launched in 1965 through a project called Pak-Japan Cooperative Scheme for the introduction of tractors and power tillers in the then East Pakistan. This program was able to make a small but significant success in disseminating the technology among a miniscule proportion of farm population. A few entrepreneurs were observed to begin exploring this new technology, particularly in the potato growing areas. The agricultural census of 1977 and 1983-84 provide some rudimentary statistics about the extent of tractor and power-tiller cultivation in Bangladesh. Only about two-tenths of a percent of cropped land was cultivated by tractors and power tillers in 1977 and in 1983/84.

The current state of mechanization is best reflected in the report of the 1996 Agricultural Census. The census data demonstrates a dramatic progress in the use of power tillers and small tractors in Bangladesh. On average, about 28 percent of cultivated land was plowed with power tillers and tractors in 1996. It seems that progress in the application of power tillers/tractors in Bangladesh was rapid in the 1990s, after the liberalization of agricultural input markets, particularly the liberalization of inputs of agricultural machinery in 1988 (Guessel, Quist,1995). However, the spread of mechanization is quite uneven among

various districts. Table 2 shows that 15 districts use power tillers on less than 10 percent of cultivated lands. Another 10 districts use power tillers to cover 10 to 20 percent of cultivated land. Thirteen districts plow 20 to 30 percent of cultivated land by power tillers. The remaining 26 districts extensively use power tillers on more than 30 percent of their land.

The use of power tillers is common among all size-groups of farmers. However, large and medium farms are found to use power tillers in a proportionately greater extent than small farmers.

Table 2 — Summary of the Extent of Diffusion of Draft Power Technology by Region, 1996

number of districts in various categories			
Under 10 percent of covered by power tillers (1)	**10 to 20 percent of land covered by power tillers** (2)	**20 to 30 percent of land covered by power tillers** (3)	**More than 30 percent land covered by power tillers** (4)
Bagerhat	Bhola	Barisal	Bogra
Banderban	Denajpur	Brahman-Baria	Chandpur
Borguna	Gopalgonj	Gaibanda	Chittagong
Gazipur	Khulna	Habiganj	Chuadanga
Jhalkati	Kurigram	Jessore	Comilla
Khagrachori	Lalmonirhat	Jhinaidah	Cox's Bazar
Nawabgonj	Moulvi Bazar	Magura	Dhaka
Norail	Nilphamari	Narayangonj	Faridpur
Panchagarh	Norsingdi	Netrokona	Feni
Patuakhali	Rajbari	Noagaon	Jamalpur
Pirojpur	(10)	Rangpur	Joypurhat
Rajshahi		Sherpur	Kishoregonj
Rangamati		Sunamgonj	Kustia
Sylhet		(13)	Lakshipur
Thakurgaon			Madaripur
(15)			Manikganj
			Meherpur
			Munshigonj
			Mymensing
			Natore
			Noakhali
			Pabna
			Satkhira
			Serajganj
			Shariatpur
			Tangail
			(26)

Source: Computed from 1996 Census Report.

3. RESEARCH QUESTIONS

The questions raised in the first section of this paper cannot be pursued systematically due to data problems. But they warrant systematic analysis. While I leave the task of systematic research for the future, I thought it appropriate to pursue empirically why some districts had a higher degree of adoption of mechanical technology than others. Previously, it was suggested that market liberalization that increased availability of cheaper machine was the primary factor for the faster spread of power tillers in recent years. But these market forces were uniform across all divisions. Then why this stark difference in adoption among districts?

Analysis of the determinants of differential adoption rates of power tillers is limited by an absence of adequate information over a period of time. The only source of information is the 1996 Agricultural Census. The Census data provide a cross-sectional picture that cannot be used for a rigorous quantitative assessment. Nevertheless, the following simple model is formulated to examine the correlates of power tiller adoption in various districts of Bangladesh.

$$PT_i = f(MLABOR_i,\ PROPIR_i,\ WANIMAL_i,\ CRINT_i)$$

Where, PT_i = the proportion of area cultivated by power tiller in the $_i$th district.
$MLABOR_i$ = male labor per acre in the $_i$th district.
$PROPIR_i$ = the proportion of irrigated area in the $_i$th district.
$WANIMAL_i$ = working animals per acre in the $_i$th district.
$CRINT_i$ = cropping intensity in the $_i$th district.

The underlying hypotheses for the relationships are as follows:

1) The literature generally argues that mechanization reduces employment because of the substitution of machine for labor. This static relation is true, however, only when mechanization does not create a substantial output that would outweigh the substitution effect. If the output effect is robust, as would be the case when the use of power tillers enables farmers to plant more area than otherwise, a positive effect on employment could

result. Therefore, a positive correlation between PT and MLABOR is expected when increases in cropping intensity accompany increases in use of the power tiller.

2) The proportion of irrigated area is also expected to influence positively the expansion of power tiller use. Two factors underpin this influence. First, irrigated agriculture creates a larger demand for both human and animal labor at the land preparation stages than non-irrigated agriculture. If land cannot be prepared rapidly after the crop preceding the irrigated crop is harvested, the extent of planting can be adversely affected. Second, farmers with irrigated land generally have a larger income than those with non-irrigated farms. These relatively rich farmers can afford to overcome credit constraints and tend to avoid arduous physical labor involved in animal traction by switching to power tillers.

3) Animal labor constraints in Bangladesh are well known because land for feed animals is scarce. Therefore, power tillers provide an opportunity to reduce the stock of cattle for plowing.

4) Because of its very high labor/land ratio, increases in multiple cropping provide one of the main sources of raising farm income. This increase in cropping intensity is made possible by rapid land preparation by power tillers. Therefore, a positive relation between PT and cropping intensity is expected.

Even though the prices of power tillers and animal power are crucial determinants of their relative usage, these factors can not be examined within the context of one year's data, when prices can be assumed as given for all districts. Therefore, the model does not explicitly incorporate price data.

With these assumptions, the results of a simple regression analysis of the model are presented below.

Table 3 — Correlates of the Use of Power Tillers (PT is the Dependent Variable)

Variable	Coefficients	Elasticity at mean	t-values	R^2
Constant	-23.4511	-	-2.017	0.57
MLABOR	21.0856	1.06	5.537	
PROPIR	0.2370	0.37	3.187	
WANIMAL	-24.3454	0.54	-2.668	
CRINT	0.1666	1.02	2.907	

Source: Estimated as described in the text.

The regression analysis reveals correlates rather than causality because the data do not permit rigorous causal analysis. Nevertheless, the strong and significant associations of the explanatory variables - labor supply, propensity of irrigation, availability of work animal and cropping intensity - with the rate of adoption of power tillers in various districts are remarkable. The explanatory power of the regression analysis is also quite high, given the cross-sectional nature of data. The significant coefficients reconfirm the relationships hypothesized earlier.

The relation between the adoption of power tillers and cropping intensity involves some circular reasoning. When cropping intensity is high and a new cheaper plowing technology than traditional bullock power becomes available, farmers with the highest cropping intensity would tend to adopt the new technology faster than farmers with lower cropping intensity. In this sense, the adoption rate is endogenous and cropping intensity exogenous. It can also be argued that given an existing level of cropping intensity, the availability of a new technology for plowing would induce farmers to adopt it and enhance cropping intensity further. Following this line of reasoning, cropping intensity is endogenous and the plowing technology is exogenous. Using this logic, another regression model with CRINT as the dependent variable and other variables of the previous model as the explanatory variables was estimated. The results are shown below in Table 4.

Table 4 — Effect of Power Tillers on Cropping Intensity (CRINT as Dependent Variable)

Variable	Coefficients	Elasticity at mean	t-Values	R^2
Constant	137.023	-	7.497	0.24
MLABOR	-5.212	0.0	-0.524	
PROPIR	0.239	0.06	1.623	
WANIMAL	10.006	0.04	0.489	
PT	0.752	0.13	2.907	

Source: Estimated as described in the text.

The results are quite different when cropping intensity is considered to be endogenous, as compared with results in the previous table where the rate of power tiller adoption is endogenous. The explanatory power of the model has dropped. Obviously, more factors than those included in the model are needed to explain cropping intensity. The land elevation of districts is known to be a basic determinant of cropping intensity but could not be included. The measurement that a 10 percent increase in power tiller cultivation results in a 1.3 percent increase in cropping intensity is nevertheless a significant finding. It implies that if use of the power tiller were to increase from its current levels of 27.6 percent to 30.4 percent of cultivated area, the cropping intensity is likely to increase from 169 to 171. This is an average and rough-order magnitude of the impact the power tiller.

HOW DO THE ORGANIZATIONS FOR POWER TILLERS OPERATE?

Perhaps there are few farmers who can own and operate a power tiller for cultivating only his own land. The holding size of most farmers would dictate that a farmer would own a power tiller and sell its services to other farmers as is commonly the case with shallow tubewells. Who takes initiative, how is the purchase of a power tiller financed and what pricing mechanism is involved in selling the services to other farmers? This information is currently not precisely known. It is also not known whether monopolistic or competitive market mechanisms are involved in provision of services. This information is necessary not only to find efficient methods of organizing services but also for monitoring whether the new technology is influencing changes in the traditional land rental market or polarizing the distribution of farm sizes in rural Bangladesh.

WHAT IS THE IMPACT ON PRODUCTION?

The production impact of power tillers is expected to occur through:

a. increased cropping intensity
b. increased yield
c. cost-savings in plowing.

Which one of these three sources of production impact is of what relative importance?

The previous analysis tends to indicate that increased cropping intensity is perhaps the most significant source of a positive impact. But this conclusion is based on cross-sectional data which might not be a true reflection of impact under a dynamic situation--to capture the dynamic effects it would be necessary to ask farmers about these dynamic effects through field surveys.

Power tiller plowing may improve crop yields through a better tillage of soil that promotes health tillering and plant growth. Experiments conducted at the Rice Research Institute indicate that the impact of better tillage on rice yield varies by nature of soil structure. Areas with hard soils get a better impact from tillage than in sandy or loamy soils. In general, the yield impact is small. However, power tiller cultivation might allow farmers to incorporate field stubble and other vegetation into the soil mass, thus improving the organic matter content of the soil. Bangladesh soils, being generally very deficient in organic matter, may derive a substantial benefit in this regard from mechanized cultivation.

The cost-saving effect of replacing bullock power with power tillers could, however, be very substantial. On the basis of some rudimentary information on prices of power tillers and bullocks, maintenance costs, operation costs and life an estimate of comparative costs of land preparation between bullock plowing and power tiller plowing has been made.

Table 5 — Estimated Comparative Costs of Land Preparation by Power Tillers and Bullock Power (Tk/Acre)

Cost Items	Power Tiller	Bullock power
1. Annual depreciation and Interest	3000	2060
2. Operation and Maintenance cost	2500	6000
Total	**5500**	**8060**

Assumptions:	Price of power tiller	20000
	Price of bullock	3000
	Plough	300
	Life of power tiller 8 years	
	Life of bullock 5 years	
	1 Power tiller for 10 acres	
	10 pairs of bullock for 10 acres	
	Interest rate 15%	

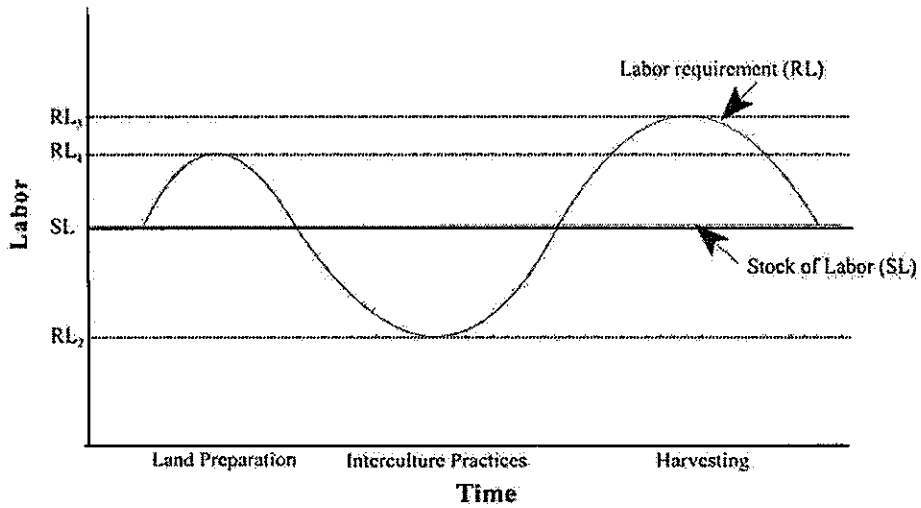
Even though the estimates are crude, it seems that power tillers cost about 50 percent less than bullock cultivation. Moreover, the implicit cost of risk involved in maintaining bullocks (eg. death of the animal), if included, would increase further the cost of plowing by bullocks. This cost savings could therefore be a powerful driving force in switching from bullock power to power tiller. It will bear implication for competitive advantage and total factor productivity of crops.

WHAT IS THE IMPACT ON EMPLOYMENT?

The employment impact of mechanized cultivation has always been a fashionable subject arousing debates and controversies. It is probably not questionable that the substitution effect of mechanization generates a negative impact on employment. But the output impact that is generated through, as for example, increased cropping intensity, is positive and may surpass the substitution effect. This theoretical proposition often warrants analysis with a careful consideration of seasonal and spatial segmentation of input markets that might render straightforward aggregation of market parameters implausible.

The nature of labor requirement in different stages of a crop-cycle (for rice) is depicted in Figure 1. In the diagram, SL represents a fixed stock of labor and RL represents labor requirements in the three broad time periods of the cropping cycle. In the land preparation cycle of a crop, the labor requirement (RL_1) exceeds labor stock, which may result in restricted area sown/planted or inadequate plowing (e.g. land plowed 3 times instead of 5). The former situation will affect cropping intensity, and the latter, the yield of the crop in question. In the inter-culture cycle, the labor requirement is typically lower than available labor stock so labor is underemployed. Of course this simple exposition relates to one crop only. In reality, a farmer grows many crops and the aggregate RL curve could be quite different. The distribution of crops determines the shape of this RL curve. It is nevertheless clear that plowing constraints in one crop will affect the production of other crops too.

Figure 1 — Seasonal Labor Distribution



This diagram can be modified to incorporate all crops and an aggregate account of labor requirement by quarters of a year can be estimated. Then, it would be possible to relate these seasonal labor requirements with seasonal wage rates. When labor requirement exceeds labor supply, as in the land preparation and harvesting phases in Figure 1, the wage rate should go up to equilibrate the supply of and demand for labor during that season. Such a model would then be able to predict what impact a labor substituting mechanical technology would bear upon the employment situation in agriculture.

Analysis of the impact of mechanization on employment will require both time series and cross section data. But time series data on employment in crop-production are not likely to be available. Most time series data on labor market are in terms of stock rather than flow of labor services. Such data will be of limited use in serious econometric analysis. Therefore, it would be essential to find out how a design of survey can be formulated to obtain data from farmers that will provide both dynamic and current facts on labor demand

and supply. It is hoped that the research agenda in the follow-up project of IFPRI will include this aspect.

4. CONCLUDING OBSERVATIONS

The evolution of the agriculture of Bangladesh into a modern sector comparable to the agricultures of East Asian developed countries cannot be conceived without a thriving role of mechanical technology. The emerging picture of the adoption of power tillers and tractors seems to be a beginning of modernity. How the process can be accelerated without any serious negative impact on employment and poverty should attract professional attention. The progress that has been achieved so far is not the result of any significant public intervention. Market forces seem to have driven the process. Therefore, it may logically be argued that studies on mechanization are not necessary. Monitoring of change without a purpose may be deemed to be a waste of resources.

I would argue against such an attitude. Historically, mechanization has always faced serious criticism on the ground of loss of employment and poverty. It may not be a too-distant in the future that donors would be swooping on the government to take preventive policies against mechanization. Whether the donors actually take such moves or not, policy makers of Bangladesh ought to know what social implications are involved in the market-driven process of mechanization. The government would then be in a position to adopt right policies as well as explain the rationales to donors.

The reduction of cattle population for draft purposes may bear a more far-reaching implication for the crop-sector, particularly in respect to total factor productivity and competitive advantage. Therefore, these aspects of mechanization warrant a serious investigation.