AMIR U. KHAN

Small Scale Machinery Development for Labour Surplus Economies

INTRODUCTION

The countries of the tropical Asian region have predominantly rural economies, with nearly 42 to 95 per cent of the population dependent on agriculture (Table 1). The total population of fourteen tropical Asian countries is about one billion, which represents nearly 30 per cent of the world population. These countries are characterised by high population growth rates and varying degrees of unemployment.

TABLE 1 *Population and numbers in agriculture; rice production area, total production and yield per hectare for selected Asian countries*

Country	Population		Rice		
	Total[c]	Agri-cultural	Area	Pro-duction	Yield
	(Million)		(Mil. ha)	(1000 MT)	(Ton/ha)
Bangladesh[a]	70.2	[d]66.4	9.48	10.99	1.2
Burma	27.7	17.5	4.97	8.4	1.7
Cambodia	7.1	5.5	1.88	2.7	1.4
India	554.6	372.6	38.8	66.5	1.7
Indonesia	121.2	83.2	8.46	18.6	2.2
Laos	3.0	2.3	0.66	0.90	1.4
Malaysia	10.8	6.2	0.52	1.53	3.0
Nepal	11.2	10.1	1.20	2.30	1.9
Pakistan[b]	66.7	26.2	11.25	18.0	1.6
Philippines	38.1	26.7	3.2	5.44	1.7
Sri Lanka	12.6	6.5	0.61	1.62	2.6
Taiwan	14.0	6.2	0.98	3.36	3.4
Thailand	36.2	27.4	6.73	13.27	2.0
S. Vietnam	18.0	13.6	2.5	5.6	2.2

Source: FAO Production Yearbook, Vol. 25, 1971. FAO, Roma.

a Source: CERES FAO Review, Vol. 5 No. 5, 1972.

b Total population for Pakistan, 131.3 less 70.0 for Bangladesh.

c Source: East Pakistan Statistical Digest, No. 2, 1964.

d Source: 1970 World Population Data Sheet.

Broadly speaking, these countries have somewhat similar agro-climatic and socio-economic conditions. With the exception of arid and semi-arid zones in India and Pakistan, the rest of the region has a humid, tropical climate. The rainy season starts about June or July and lasts for approximately four to five months, with rainfall varying from 26.0 to 93 inches per year.[1]

The important agricultural crops in the region are rice, wheat and corn. Wheat is an important crop in the semi-arid regions of India and Pakistan. For the rest of the tropical Asian region, rice is the single most important crop and the economies of these countries are heavily dependent on it. It has been estimated that nearly 90 per cent of the world's rice is grown in this region[2] Table 1 includes figures on the major rice-producing countries in Asia. Rice is grown on 91.24 million hectares with an estimated annual production of 159.21 million metric tons in the tropical Asian region.

Land and labour productivity is quite low in tropical Asia, which results in a poor standard of living for a majority of the rural population. The average farm is small, with over 95 per cent of farm holdings falling below 10 hectares in size.[1] Almost all of the crops produced on small farms in the tropical Asian region are presently cultivated by non-mechanical methods. Small holdings, low farm incomes, and different production practices are often cited as the major problems in transferring agricultural mechanization technologies from the temperate regions. In addition, many fear that mechanization of tropical agriculture may lead to serious unemployment and socio-economic imbalances in the region. Recent developments, however, are beginning to create a more favourable climate for agricultural mechanization in Asia. An important issue facing most Asian countries, is concerned with the strategy that must be followed for mechanizing their agriculture to increase food production without creating any undesirable imbalances.

PRESENT STATE OF MECHANIZATION

Mechanization of tropical agriculture is a rather complex question due to its social and economic impact on the rural population. The author firmly believes that the techniques that produce 20 kg of rice with only 5 to 7 minutes of labour in the United States have little justification for application in the labour-surplus economies of tropical Asia. At the same time, however, low labour productivity in tropical agriculture must be raised through mechanization to provide a decent standard of living for a majority of the Asian farmers.

The power available in agriculture, both per hectare and per man, is a good indicator of the level of agricultural mechanization in a country. Table 2 indicates the horsepower per hectare and per man in eleven tropical Asian countries along with data from Japan which has one of the most mechanized agricultures in the world. Many authorities have under-

TABLE 2 *Some agricultural mechanization indicators in eleven rice-producing countries in Asia.*

Country	Arable land per holding (ha)	Agri-working popu-lation per ha	Horsepower per hectare				Hp per agricultural worker	Labour hours for rice cultiva-tion/ha
			Human	Animal	Mech-anical	Total		
India	2.62	0.90	0.090	0.204	0.008	0.249	0.009	1000
Iran	6.17	0.37	0.037	0.048	0.154	0.292	0.418	n.a.
Japan	1.06	2.16	0.216	0.120	2.664	3.000	1.231	1400
Korea	0.90	1.96	0.196	0.236	0.003	0.435	0.0013	830
Nepal	1.22	2.49	0.249	0.480	0.004	0.733	0.0016	n.a.
Pakistan	2.37	1.09	0.109	0.288	0.013	0.410	0.012	n.a.
Philippines	3.66	0.71	0.071	0.104	0.023	0.198	0.030	800
Sri Lanka	1.59	1.20	0.120	0.148	0.110	0.378	0.009	n.a.
Taiwan	1.11	1.95	0.195	0.164	0.146	0.505	0.074	1300
Thailand	3.64	1.10	0.110	0.184	0.054	0.348	0.050	n.a.
Vietnam	1.57	2.10	0.210	0.244	0.023	0.477	0.004	n.a.

Source: APO Expert Group Meeting on Agricultural Mechanization, APO Project SYP/III/67, Tokyo, October 1968, Vol. II.

standably pointed out that insufficient power in agriculture is a major problem in the developing countries. In the tropical Asian countries average power input from all sources, human, animal and mechanical, is 0.19 hp/ha in agriculture.[3] It has been estimated that at least 0.5 hp/ha is required to achieve respectable crop yields.[4] For a variety of reasons, it seems doubtful that additional power could be provided in these countries from human or animal sources.

If agricultural mechanization is to be one of the means for economic and social uplift of a large segment of the rural society, it must cater to the needs and aspirations of the small farmers. Today the majority of small farmers are facing a dilemma. On one hand, they must intensify cultivation, which can be economically done only through mechanization, on the other hand, mechanization technologies to meet their crop production requirement within their economic and social framework is generally not available.

THE CURRENT DEBATE

Two somewhat opposed premises are often put forward for the mechanization of tropical agriculture: (1) That mechanization of agriculture will create unemployment and will lead to many socio-economic problems, hence, mechanization is not only unnecessary but also harmful. (2) Shortage of power is the essence of the agricultural mechanization problem and large, high-powered equipment can provide this power in the most economical manner, hence, mechanization of tropical agriculture with large tractors and equipment would be most economical and desirable. Proponents of these two diametrically opposed viewpoints put forward seemingly convincing arguments to support their hypotheses.

The fear that mechanization of agriculture will lead to large labour surpluses in the developing countries seems a little unjustified. Recent studies in the Philippines indicate that the progressive farmers who adopt new seed-fertilizer technology are more inclined towards intensive cultivation through mechanization. Japan is another interesting example where, in spite of the most mechanized agriculture in the world, labour utilization in rice production is still among the highest in Asia (Table 3).

These cases clearly indicate that mechanization is possible without displacing labour for farming. It is important however that mechanization strategies for the developing countries must not only be based on a thorough understanding of the functional requirements and constraints but must also consider the socio-economic implications and the aspirations and goals of the developing countries.

AGRICULTURAL DEVELOPMENT

Developments in the seed-fertilizer technology have demonstrated that it

is possible to raise crop yields in the tropics by several-fold. To obtain maximum benefits from modern seed-fertilizer technology, farmer must keep his land in near continuous production. Many studies have indicated that demand for labour in rural Asia is highly seasonal. In spite of high rural unemployment in many parts of Asia, labour shortages are beginning to occur in peak labour demand periods. Many farmers find that they cannot effectively till, transplant, and harvest their crops with traditional methods due to a shortage of labour. In addition, the cost of labour in most Asian countries has been rising steadily over a number of years. In Pakistan, of which I have more recent personal experience, availability of farm labour is becoming a serious problem in many parts of the country. The shortage is so serious that some farmers have been reported to have left their land fallow due to non-availability of labour.

Matsubayashi, et al.[5] found that in Japan the major labour-consuming operations are: land preparation 15 per cent, transplanting 15.3 per cent; weeding, 15.41 per cent, harvesting and threshing, 33.5 per cent. They also found that labour requirements in the peak-labour demand months is about 60 times that of the minimum monthly labour requirement. A study of farm labour requirements in the Laguna Province and the Central Luzon areas of the Philippines[6] indicates that the labour requirements for land preparation, transplanting, and harvesting–threshing of paddy are 32 per cent, 23 per cent, and 27 per cent, respectively, of the total labour inputs in paddy cultivation. In the double-cropping areas, harvesting–threshing of the first crop and the land preparation and transplanting of the second crop require 82 per cent of the total labour inputs in a short period of four to five weeks. Timeliness of operations is an important factor in the double-cropping areas because the second crop must be transplanted in time to take maximum benefit from the late rains. The mechanization of cultivation is, therefore, an urgent necessity in many parts of tropical Asia.

TABLE 3 *Labour hours for rice cultivation in some selected Asian countries*

Country	Land preparation	Transplanting	Harvesting	Total (including others)
India	170	229	227	1000
Japan	50	240	220	1400
Korea	160	160	160	830
Nepal	240	240	240	n.a.
Philippines	190	120	170	800
Taiwan	60	190	220	1300

Source: APO Expert Group Meeting on Agricultural Mechanization, Vol. II, (APO Project SYP/III/6767), October 1968.

TECHNOLOGY TRANSFER

There are two distinct agricultural mechanization technologies that have evolved to suit different agro-climatic, socio-economic and industrial conditions in the world. The Western approach emphasizes dryland farming with large, high-powered equipment. A remarkable saving in labour input has been achieved here either through the use of large, high-powered equipment or by combining many farming operations in a single pass of the machine. Widespread application of such a labour-saving technology in the tropical region would certainly cause serious dislocations. Crops and cultivation practices of the tropical Asian region, as well as the scale of farming operations, are quite different. In addition, Western farm equipment is designed for manufacture with highly capital intensive, mass production methods that are not available nor recommended for developing countries of Asia.

Agricultural mechanization in Japan has not followed the Western pattern. Small farm holdings, high price support for rice, coupled with rapid industrial growth, has resulted in the mechanization of Japanese agriculture with small, low-powered but highly sophisticated machines. Japanese farm equipment has been primarily developed to meet the complex requirements of farmers who are more prosperous, better educated and more mechanically minded than those in tropical Asia.

Experience indicates that the Japanese agricultural mechanization technology is uneconomical and too sophisticated for tropical Asian conditions. The Japanese transplanters, reaper binders, combine harvesters are interesting examples of popular Japanese farm equipment which have failed to find a market in tropical Asia.

An important factor which cannot be ignored in introducing foreign manufactured equipment is that the balance of payment problems for most countries in tropical Asia is not expected to improve in the near future to permit any large scale imports of agricultural machines.

IMPORT VERSUS LOCAL PRODUCTION

Considerable scope exists in the developing countries for the manufacture of tractors and other agricultural machines. Mechanization of agriculture and local production of farm machines are so closely related that the establishment of a local farm equipment industry is almost a prerequisite for widespread agricultural mechanization. Manufacturing technology in the industrialized countries has advanced to a highly capital intensive level. The socio-economic climate in the developing countries does not lend itself to such an advanced technology.

Quite often a convincing argument is put forth by established farm machinery manufacturers from the industrially advanced countries that sufficient demand does not exist in the developing countries to justify local production. There is no doubt that economies of scale are very

important in the high labour-wage economies of the industrialized world. More often, however, low volume production with labour intensive methods can be economically organized in the developing countries if machinery designs and production methods are appropriately tailored to suit local conditions.

During the last few years, many interesting cases of economic low-volume production have been successfully demonstrated in Asia. Local production of small four wheel riding tractors and power tillers in Thailand and in the Philippines are excellent examples. The manufacture of the Jeepney in the Philippines, on an almost cottage industry basis, is another interesting example of product and production process adaptation for low volume production. Similarly, locally developed three wheel auto rickshaws and farm trucks are being economically produced by small metal working firms in Taiwan.

Production of the IRRI power tiller in the Philippines is another interesting example. The tiller design was started in late 1971 at the International Rice Research Institute with the specific objective of developing a simple machine that could be fabricated by small metal working shops with standard equipment. Care was taken to limit the production operations to simple cutting, bending, welding and machining operations. Extensive use of readily available components such as air cooled engines, motor cycles and automotive parts, roller chains and sprockets were utilized in the power tiller design. Within a short period of about eight years this tiller is being widely produced in the rural areas of the Philippines and Thailand.

MECHANIZATION STRATEGIES

In most developing countries of Asia, agricultural land holdings can be broadly categorized in three size groups; small (less than 2 hectares), medium (2–10 hectares) and large (above 10 hectares). The small farm holdings group is characterized by subsistence farmers and comprises the largest number of farm families. The medium size farm holdings cover a substantial cultivated land area and support a fairly large number of farmers. The large farm holdings usually cover a relatively small cultivated land area with few farmers dependent on such holdings.

From a socio-economic point of view, the small and medium size farm holdings are of much greater importance in the developing countries. Medium and large farm holdings, however, play a significant part in producing surplus food that is needed to feed the urban population. Mechanization of these three levels of farm holdings require somewhat different strategies. A brief discussion of the suggested strategies for these three categories of farm holdings is given below:

1 *Small farm holdings (less than 2 hectares)*
This category of farm holdings consists primarily of subsistence farmers

who do not have much surplus cash resources to mechanize agriculture with individually owned machines. Primary focus for increasing food production for this operational level needs to be placed on providing improved divisible inputs such as seeds, fertilizers, insecticides etc. along with improved labour intensive cultural practices. This group of farmers depend primarily on manual or animal drawn implements for their farming operations.

Most farms in this category are too small to be attractive to large tractor pool operators or contract operations. Attempts to mechanize operations on such farms through large Government operated tractor and machinery hiring pools are not expected to produce any significant results in most developing countries. A more promising approach for providing an intermediate level of mechanization would be to encourage renting of tractors and farm equipment from medium and large size neighbouring farms. Such a strategy has proved rather successful in South East Asia where small farm machines such as power tillers, threshers as well as large tractors and other farm machines are being used for contract operations on neighbouring farms.

There is, however, considerable scope for introducing new and improved manual and animal drawn implements on such farms. Past experience in most developing countries however indicates that efforts on the design and development of new or improved manual and animal equipment have not been too productive. It would be more beneficial to transfer promising manual and animal drawn equipment from other countries with similar agro-climatic conditions. Thus a mechanization strategy based on testing and evaluation of new farm equipment from other regions and extension and local manufacture of the promising equipment would be more appropriate for mechanizing such holdings.

Since location specificity is rather high for manual and animal drawn implements, extension of such equipment among farmers as well as rural workshops would require considerable efforts from the public agencies. Most manual and animal drawn implements are fairly low in cost and are not amenable to manufacturing in centralized plants and marketing on a national basis. For this reason, manufacture of such equipment in close proximity to the end users, i.e. in villages and rural towns, would be the appropriate strategy.

2 *Medium size farms (2-10 hectares)*

Most farms in this category can afford an intermediate level of farm mechanization. Because of a lack of appropriate equipment, such farm holdings are forced to use traditional methods. Tractors and other farm machines from the industrialized countries, are often too large and high priced for this group of farmers. Traditional farm equipment are also uneconomic for their operation. Such farmers are in a dilemma for even though they could mechanize their farm operations, appropriate machines to meet their needs are not generally available. Lack of commercially viable designs of power tillers, small tractors, implements and

other farm machines are serious bottlenecks in the mechanization of this major farm group today.

In most industrialized countries farm equipment is developed by machinery manufacturers to meet local farming requirements. This equipment is subsequently marketed in the developing countries to expand sales. It is somewhat unrealistic to expect that industrialized countries manufacturers would develop appropriate farm equipment for the medium size farm holdings in the developing countries. The developing countries, must, therefore, look to themselves for generating appropriate small farm equipment designs to meet their own needs. Since farm equipment manufacturers in Asian countries are not yet capable of developing appropriate equipment, greater efforts are needed from the public research institutions on the design and development of appropriate farm equipment for the medium size farms. This medium category of farms will generally require farm machines that would be powered with small 5–12 hp. medium and high speed diesel engines. Efforts must, therefore, be made to manufacture such engines to accelerate the development of appropriate mechanization technologies for the medium size farms.

While this category of farms could benefit from centralized Government tractor and farm machinery hiring services, efficient management of such services is generally a chronic problem. For this reason, development of private tractor and machinery hiring contractors and hiring by neighbourhood farms offer much greater hope, as discussed earlier. Since equipment for the medium size farm holdings will be of a somewhat higher complexity than for the small farm holdings, production of such intermediate would have to be organized in the larger market towns and medium size cities in the country.

3 *Large farms (over 10 hectares)*

This category of farm holdings can be adequately served by the mechanization technology that is currently being imported from the industrialized countries. Some degree of selective mechanization may be necessary to minimize undesirable socio-economic effects. Some restrictions are necessary to limit imports of tractors and equipment to a few makes in the developing countries. This will permit development of stronger marketing and distribution channels and would ease the problems of spare parts and service availability. Wherever market demand justifies, production under a limited period licence from the original manufacturers is a desirable strategy to maintain product quality and encourage indigenous production in the country.

IRRI MACHINERY DEVELOPMENT NETWORK

Machinery design and development is primarily an industry function in

the industrially advanced countries. Because of the struggling state of the farm equipment industry in the developing countries, industry is not in a position to invest funds in R & D. Consequently, little commercial style R & D is done in the developing countries.

Recognizing this bottleneck, the International Rice Research Institute in the Philippines started a programme in 1967 on the development of low cost rice production machines for local manufacture in the Asian countries. The IRRI Machinery Development Programme is primarily focused towards meeting the requirements of the medium size farmers. With modest beginnings in the late sixties, the IRRI programme has developed into a major source for designs of appropriate wetland rice cultivation equipment for the medium size farm holdings. The IRRI machines are now being commercially produced in thirteen developing countries and are gaining popularity in other parts of the world. Table 4 indicates the growth in the production of the IRRI machines and the funds expanded on the IRRI machinery development programme. As of December 1977 a total of 95,000 IRRI designed machines were commercially produced by co-operating IRRI manufacturers in Asia.

In order better to disseminate and adapt the machinery designs to other areas, three regional industrial extension programmes have been established in Thailand, Indonesia and Pakistan. The Institute also has co-operative industrial extension programmes with Universities and research organizations in nine other countries. The IRRI–PAK Agricultural Machinery Programme in Pakistan is focusing its attention on adapting and introducing the IRRI machines to rain-fed and irrigated dryland farm conditions that are prevalent in this region.

Experience gained with the IRRI outreach machinery programmes indicates the importance of local adaptation in introducing new technologies. The IRRI industrial extension programmes have introduced many IRRI machines to manufacturers in their respective regions after testing and adapting these to suit local conditions. The IRRI Programme has amply demonstrated the returns that could accrue through appropriate R & D efforts for small farmers in the developing countries.

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DISCUSSION OPENING – HAROLD C. LOVE

I 1 Mr. Khan's paper deals with some of the most challenging and important problems of developing world agriculture. He gives a progress report on relevant and innovative research conducted by the International Rice Research Institute.

2 Twenty-eight Asian countries produce about 90 per cent of the world's rice. Mr. Khan's paper selects 14 Asian countries for study. These countries produce 50 to 55 per cent of Asia's rice.

3 The paper considers three facets of mechanization in agriculture:
(1) Population and labour problems;
(2) The dilemma between mechanization and surplus labour and,
(3) Research and development of locally produced tractors and tillers for developing countries by IRRI.

4 All Tables in the paper (except No. 4) use 1968 to 1972 data. It is therefore appropriate to support and emphasize Mr. Khan's major headings with recent trends 1970–77 for the countries selected. We begin by adding Table 1-A.

II Population and labour problems

1 Note: a) The trends in Table 1-A and
b) Total population grew at an annual rate of 3.5 per cent.

2 The working force, or economically active population's annual growth was 2.1 per cent.

3 During the seven years, the agricultural working force declined 5.3 as a per cent of the economically active population.

4 Annual growth of agriculture's economically active work force was only 0.92 per cent. This low growth trend is one major stimulant for mechanization in agriculture.

5 Finally, note lines four and five of Table 1-A. In spite of favourable production conditions during 1977, per caput domestic production was 7.5 kilograms below 1970. (In 1977 Taiwan and Japan were in export positions for rice and were encouraging the production of maize and other crops. Indonesia was still a net importer.)

III *The dilemma between mechanization and surplus labour*

1 Most of Asia's production of rice and other crops depends on human power. They are about where US agriculture was 150 to 200 years ago.

TABLE 4 *Expenditures and sales patterns for IRRI agricultural machinery development programme, 1962—77*

Year	Programme expenditures CA-CORE	USAID 1208	Total	No. of machines produced	Sales value	R & D expenditures as % of sales	Av. selling price
	US$	US$	US$		US$	%	US$
1962	3,639.85	—	3,639.86				
1963	9,414.61	—	9,414.61				
1964	10,213.91	—	10,213.91				
1965	20,535.44	—	20,535.44				
1966	56,307.49	—	56,307.49				
1967	101,330.58	—	101,330.58				
1968	131,782.85	—	131,782.85				
1969	108,549.05	—	108,549.05				
1970	123,982.05	—	123,982.05	50	19,248.01	644.0	384
1971	194,366.31	—	194,336.31	2,200	831,011.91	23.0	377
1972	236,270.79	—	236,270.79	4,400	1,662,023.82	14.0	377
1973	253,534.50	—	253,534.50	6,600	2,493,872.60	10.0	377
1974	366,343.53	—	365,343.53	8,900	3,362,543.66	11.0	377
1975	273,000.00	36,367.31	309,367.31	17,258	5,765,000.00	5.0	336
1976	340,000.00	262,147.32	602,147.32	30,451	11,187,697.40	5.0	367
1977	437,000.00	393,204.22	830,204.22	34,847	12,302,787.80	6.0	367
Total	2,665,270.97	691,718.85	3,356,989.82	104,706	38,124,185.20	9.0	364

2 A country may judge its relative stage of development by the percentage of its population in agriculture. In Mr. Khan's selection Nepal and Taiwan represent the range with 93 and 48 per cent respectively. Yet Taiwan with its high rice yields and mechanization uses 1300 hours of labour per hectare and Japan with even greater mechanization uses 1400 hours.

3 The number of agricultural tractors in use each year in the fourteen Asian countries is only a rough measure of mechanization. Such data does not indicate horsepower per unit, or hours of use annually. However, in 1967–71 these countries had 185,000 tractors; but in 1976 there were 369,000 in use. This is a compound annual growth rate of 12.2 per cent. It is an impressive trend toward mechanization.

4 Timely operations during tillage, seeding and harvest are critical for double cropping rice production. Yet severe labour shortages occur in many Asian countries especially at harvest time. In the future, a type of mechanical harvesting will be needed to alleviate this shortatge.

5 Providing some mechanization for millions of small holder rice producers remains a critical challenge. Mr Khan's paper suggests: (1) custom work hired from neighbouring larger farms; (2) new and improved manual and animal drawn implements; (3) testing and evaluation of new farm equipment from other regions and extension and local manufacture of the promising equipment; and (4) manufacture of such equipment in close proximity to the end users, e.g. in nearby villages or small towns.

IV *Research and development by IRRI*

1 The IRRI machinery development programme is a good example of how new machines and techniques can be introduced.

2 Based on the IRRI's progress to date the governments of developing countries may begin to give high priority to investing some of their scarce resources in this type of research and development. As agricultural economists we can support and encourage such action.

GENERAL DISCUSSION – RAPPORTEUR: JUAN CARLOS MARTINEZ

The general discussion of Dr Khan's paper was developed basically around the following issues:

1 Is the mechanization discussed in the paper economic from the perspective of the farmer, assuming he is paying the full cost of the equipment, operating and maintenance cost?

2 Is the small farmer financially able to handle the increased capital requirements associated with mechanization and its implications in terms of increased flows of production?

3 The experience in project evaluation in labour surplus economies involving mechanized technological alternatives has consistently given negative benefit/cost relationships. Can we then advocate these types of technologies for these countries?
4 The concern of the paper deals with labour surplus economies. What will be the implications of adding to this the consideration of the energy situation; in particular, the increase in the price of petroleum?

Dr Khan's replies are summarized as follows:

1 The evidence indicates that it is economic and financially feasible from the point of view of the farmer to meet the capital as well as the operating and maintenance cost of the type of mechanization discussed in the paper. One of the reasons for this is that the costs are not too far off the ones implied in the traditional methods. This is one of the innovative aspects of the type of mechanization advocated in the paper.
2 The negative benefit/cost ratio currently found in project evaluation for mechanized technologies refers to designs coming from the developed world and not to the kind of mechanization advocated in the paper.
3 There is no question that shortage and increase in the cost of energy will complicate the situation. Simultaneously, cost of labour is also increasing in most countries. In any case, it is becoming essential that more intensive cultivation be introduced; which seems difficult, if not impossible to do without mechanization.

TABLE 1–A *Population and production trends for 14 selected Asian countries for the years 1970 through 1977*[1]

Year	1970		1977
Total population (millions)	925.31		1,176.18
Annual population growth %		3.5*b*	
Annual rice production (1000 metric tons)	153,341*a*		186,013*a*
Per capita domestic production (kilograms)	165.7		158.1
Net change (kg.)		7.5	
Economically active population (millions)	383.43		442.99
Annual growth rate %		2.1*b*	
Economically active population in agriculture (millions)	265.82		283.56
As % of active population	69.3		64.0
Annual growth rate %		0.92*b*	

Sources: 1971 and 1977 FAO Production Yearbooks; 1978 Yearbook Encyclopedia Britannica; USDA Foreign Agricultural Service, and 1978 Commodity Yearbook, Commodity Research Bureau, New York.
[1] Bangladesh, Burma, Cambodia (Democratic Kampuchea), India, Indonesia, Laos, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand and Vietnam.
a The selected countries produce 52 to 55 per cent of total Asia rice production.
b Computed as an annual compound rate $(1 + i)^n$ from data given.