Economic Evaluation of Appropriate Agricultural Machinery in Indonesia

By MITSUO SUZUKI*

Department of Farm Mechanization, National Agriculture Research Center
(Tsukuba, Ibaraki, 305 Japan)

Introduction

Indonesia is the largest archipelago country in the world. In 1987, the population was approximately 175 million, out of which approximately 65% lived in the Java Island which has only 7% of the entire area of Indonesia. Approximately 55% of those who are engaged in jobs are farmers. Table 1 shows harvested area, production and yield each of rice and secondary crops in Indonesia. A main food crop is rice and the first self-sufficiency of rice supply was accomplished in 1984. Rice could be cultivated three times a year in case where the land could get enough water for irrigation. However, the government recommends the farmers to grow rice two times a year with company of planting a secondary crop.

Agricultural machinery employed in farming during the period 1981 to 1986 are shown in Table 2. The most predominant agricultural machine is a hand sprayer, followed by a rice thresher. However, the total number of these machinery is far less than that in the other ASEAN countries.

Agricultural mechanization in Indonesia is stratified into four stages. Comparatively large scale machines such as tractors and water pumps were imported and used for the first time in the first stage (1950–1960). Small scale machines were introduced during the next stage (1960–1970) and use of those machines gradually expanded during the third stage (1970–1980). The National Farm Mechanization Committee was set up in this stage.

With the objective of developing an appropriate agricultural machinery suitable for Indonesia, the Center for Development of Appropriate Agricultural Engineering Technology was established in April 1987 under the bilateral cooperation between the Government of Japan and the Government of Indonesia. The Center is located in Legok, Tangerang, West Java, about 35 km away from Jakarta. Several machines such as a power tiller, a reaper, a multicrop thresher and a dryer have been developed under the Center's projects. Table 3 shows the specifications of the prototype machines brought about by the Center.

Present address:
* Center for Development of Appropriate Agricultural Engineering Technology (Serpong, Tangerang, West Java, Indonesia)

Table 1. Production of rice and secondary crops in Indonesia (1986)

Crops	Harvested area (1,000 ha)	Production (1,000 t)	Yield (t/ha)
Rice*	9,988	39,726	3.98
Maize	3,143	5,920	1.88
Soybean	1,254	1,227	0.98
Peanut	601	642	1.07
Cassava	3,143	13,312	11.38
Sweet potato	253	2,091	8.26
Mungbean**	286	200	0.70

* Dry unhusked rice.
** 1985.
Source: Statistical year book of Indonesia 1986, Central Bureau of Statistics of Indonesia (1987).

Table 2. Number of agricultural machinery in Indonesia

Year	Tractor		Thresher*	Dryer	Hand sprayer	Rice milling unit
	Two wheels	Four wheels				
1981	4,845	3,859	15,149	1,111	382,731	49,368
1982	6,443	4,061	11,731	837	464,922	47,279
1983	7,642	4,074	23,657	1,121	510,870	52,675
1984	8,881	4,122	34,424	975	570,039	46,360
1985	9,936	4,352	65,524	846	652,206	56,920
1986	11,219	4,175	82,146	1,009	724,121	59,855

* Including pedal thresher.
Source: Agicultural machinery by province and district (yearly), Central Bureau of Statistics of Indonesia.

Table 3. Specifications of prototype machines

Machine	Overall length (mm)	Overall width (mm)	Height (mm)	Weight (kg)	Capacity	Remarks
Power tiller	2,350	800	1,100	250	5 a/hr	Tillage width : 60~ 80 cm
Reaper	2,315	1,470	1,010*	114**	30 a/hr	Cutting width : 120 cm
Power thresher (Multi-crop type)	1,190	1,320	1,500	200	500 kg/hr	Drum diameter : 380 mm Length : 800 mm
Dryer furnace	830	590	990	350	5 kg/hr	Rice husk

* Maximum height. ** Dry weight.

Methodology

The following two methods are available in appraising an investment: (a) estimation on the undiscounted measures, and (b) estimation on the discounted measures. In the undiscounted techniques, a breakeven point (BEP) and a payback period (PBP) are employed in this paper. In the discounted techniques, an internal rate of return (IRR) and benefits cost ratio (BCR) are employed. The formula each is:

Annual fixed cost + Variable cost × (X)
= Benefits or custom fee × (X),
where X = Breakeven point (ha, t or hr/year);

PBP = Initial investment/Average annual net benefits;

IRR = Lower discount rate + Difference between the two rates × Present value of the cash flows at the lower rate/The absolute difference between the present value of the cash flows at the two discount rates;

BCR = Present value of gross benefits/Present value of gross cost.

A conversation type program for the personal computer was developed on the basis of the above mentioned formula.

Background

There are many factors which have to be taken into account in economic analysis of agricultural machinery. Some assumptions are given, as explained hereafter, on the basis of the predominant conditions of agriculture in Indonesia, where the machines would be introduced. Those conditions were presumed from the results of the surveys which were undertaken in 1988.

A farmer has 2 ha of his own land and grows a rice crop two times a year with company of growing a secondary crop. He uses his machines for a custom work after completion of cultivation of his own land.

Expected life of machines is generally of 5 years except for that of a tractor, which is of 8 years. A farmer works for 5 hr in the morning and the wage of the machine operator costs approximately Rp2,500/day. He replaces his own hand labor by a machine and the replacement is taken into account in estimating the breakeven point. Rice plants are harvested when the grain moisture contents reach about 25%. The average yield is approximately 5.6 t/ha in a wet unhusked form, which is valued at about Rp175–190/kg. A farmer can sell the produce at a price of Rp250/kg on a basis of grains with a 14% moisture content. It costs Rp450/l for gasoline and Rp250/l for kerosine. A special loan with a low interest of 12% per year is available under the subsidy from the government for the farmer to purchase an agricultural machine, while a general bank interest is approximately 22%.

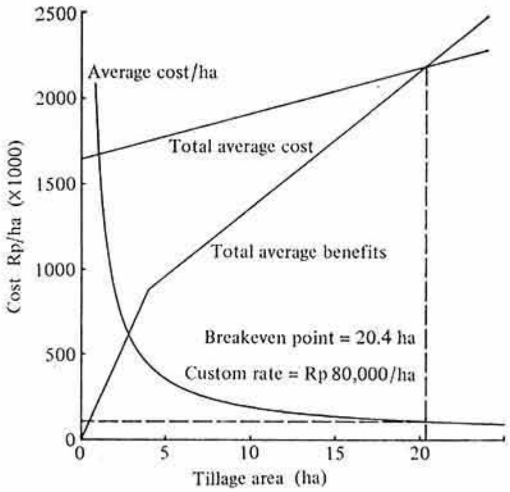

Fig. 1. Breakeven point in operating power tiller

Table 4. Basic information for the use of power tiller

Item (Unit)		Amount
Investment cost	(Rp)	4,500,000*
Bank interest rate	(%)	12
Machine life	(year)	5
Salvage value	(10% of IC)	450,000*
(=Repair & maintenance)		
Machine capacity	(ha/hr)	0.05
Fuel consumption	(l/hr)	1.3
(Diesel engine: 6 HP)		
Wage rate	(Rp/day/person)	2,500*
Custom rate	(Rp/day)	80,000*
Average yield	(t/ha)	5.6
Price of dried paddy	(Rp/kg)	210*
Annual working area	(ha)	30

* ¥=Rp13.5.

Table 5. Costs and benefits of the power tiller investment

Costs and benefits		Amount	Remarks
Initial cost (IC)	(Rp)	4,500,000	
Fixed cost	(Rp/year)	1,647,000	
Annual depreciation*		810,000	
Interest on average investment**		297,000	
Repair and maintenance	(10% of IC)	450,000	
Tax and insurance	(2% of IC)	90,000	
Variable cost	(Rp/ha)	26,600	
Labor		20,000	
Fuel		6,300	
Oil		300	
Benefits	(Rp/ha)	220,000	From the work on farmer's own land
		80,000	Custom work

* Depreciation = (Initial cost − Salvage cost)/Machine life.
** Interest on average investment = (Initial cost + Salvage value)/2 × Bank interest.
Breakeven point (ha/year : 2 season) = 20.3,
(hr/year : 2 season) = 406.0,
(day/year : 2 season) = 81.4.

Power tiller

The power tiller used installs steering clutches and a transmission with three forward-speeds and one reverse-speed and mounts a 6 horse-power (HP) diesel engine. Its initial cost is estimated at Rp4,500,000.

The following conditions are assumed for economic analysis of the power tiller: man-powers required to till 1 ha are 450 man-hr and 20 machine-hr. A farmer earns Rp80,000/ha in his custom work.

Basic information as well as costs and benefits of the use of a power tiller are shown in Tables 4 and 5 for a representative case. The breakeven point in operating the power tiller is also shown in Fig. 1. The total average benefits at the initial stage, being rather low, are obtained mainly from the farmer's on-farm activities on his own land, while the benefits at the following stage are attributed mainly to the income from his custom work. The custom work fee seems to be too low in this analysis. However, the fee amounting to Rp80,000/ha for two times of tillage is predominantly paid in Indonesia at present.

The breakeven point corresponds to 20.4 ha/year (or 407 hr/year), which seems to be reasonable. However, the point reaches 25.6 ha/year (or 512 hr/year) in case where the machine mounts a gasoline engine. This means that a power tiller mounting a diesel engine is more profitable for the farmer.

Reaper

The machine, mounting a 3.5 HP gasoline engine, has only a forward speed without a reverse speed and steering clutch. The initial cost of a reaper is estimated at approximately Rp3,500,000. Labor requirements for harvest are 100 man-hr/ha by hands and additional 4 machine-hr/ha by a reaper. The custom rate is estimated at approximately Rp60,000 in this analysis. Cutting loss is 2.5% by the traditional method and 0.5% by the reaper harvesting. The breakeven point corresponds to 23.1 ha/year (or 92.4 hr/year), which seems to be a realistic estimate.

Multi-crop thresher

The threshing machine has been designed not only for rice but also for soybean, installing a straw rack. The initial cost is estimated at approximately Rp2,500,000, including a 5 HP gasoline engine. The traditional method by hand hitting can thresh about 40 kg/hr of paddy rice with a grain loss of approximately 2.5%. A farm laborer for harvesting usually receives an amount of one-fifth to one-seventh of his/her paddy harvest as a wage in kind in Java Island. The threshing capacity of a machine is estimated at 500 kg/hr with a lower grain loss of about 0.5%. The custom rate is assumed to be Rp60,000/ha.

The breakeven point corresponds to 19.3 ha/year (or 216 hr/year), which also stands on a quite adequate level.

Dryer

A rice husk furnace has already been made available as a heat source of the dryer under testing, though a drying box is still under designing. The holding capacity of the dryer is 1,000 kg of paddy. The initial cost is estimated at approximately Rp2,500,000 with a 5 HP gasoline engine which drives a blower for the heated air. Since the engine of the dryer could also be used for multi-purposes, the initial cost goes down to the level of Rp1,200,000 in such a case.

The breakeven point corresponds to 3.1 ha/year (or 17.4 times/year). This figure indicates that a farmer can earn a good deal of profits from his own investment without any custom work. In Indonesia, a dryer has been seldom used possibly because sufficient solar energy is available for drying paddy even in the rainy season. The critical problem in this connection, however, is that farmers sell their paddy harvest in a wet and high moisture grain condition on the field. The harvested grains are bagged without drying, resulting in lower prices than the case in the dried produce. Quality deteriora-

Table 6. Results of investment evaluation for prototype machines

	Initial cost (Rp×1000)	Engine horse power (HP)	Working area (ha/year)	Breakeven point (ha/year)	Payback period (Year)	Internal rate of return (%)
Power tiller	4,500	6.0	27	20.4	3.6	11.6
Reaper	3,500	3.5	28	22.8	3.6	11.8
Power thresher	2,500	5.0	24	19.3	3.6	11.2
Dryer	2,500	5.0	3.1	1.8	1.5	18.1
Tractor: cf	22,000	20.0	105	81.4	4.9	11.9

US$=¥125=Rp1,735.

tion would take place rather often under these conditions, especially in the humid tropics including Indonesia. In order to alleviate such constrains, agricultural extension services at the farm level will play an important role in promoting artificial drying which should be economically viable.

Tractor

A four-wheel tractor which mounts a 20 HP diesel engine is subjected to the analysis for reference. The estimated breakeven point indicates that the tractor owner has to work for about 195 days/year to fully depreciate his investment under the condition that he can earn Rp100,000/ha as a custom fee. Such a heavy load is caused by the high initial cost for the tractor purchase. One of the ways to be relaxed from the load would be to develop group acquisition and utilization, which might give the investors an opportunity to earn some profits in the relevant investment.

Conclusion

The results of the investment evaluation for prototype machines are shown in Table 6. This evaluation is based on the benefits cost ratio of approximately one, namely, a farmer does neither earn nor loose any profit in his investment, as well as on the internal rate of return nearly equal to the loan interest in this point. Each case of the farm mechanization presented in Table 6 shows that if a bank loan with a low interest rate is available for agricultural machinery, the relevant investments could be depreciated in a few years and ensure significant profits. Furthermore, there is another serious constraint to the farm mechanization that the existing custom rate is too low for the machine owners.

Among the agricultural machines examined in this analysis, the dryer is likely to be most profitable from the view point of economic viability. However, its number at working is very limited at present. The thresher follows the dryer in terms of its profitability, but it would further need a critical analysis of its economic viability and related aspects before the introduction in Java Island.

One of the key issues in the wider use of these machines by the farmers is lack of the chance of investment for investors in Indonesia, because needed stocks of almost all types of agricultural machines are not available there at present.

It is required for a machine owner to be engaged in a custom work in order to earn a profit after completion of his own farming. In this connection, a complaint has been expressed by the farmers interviewed during the field survey that machine operators' works under contracting were not adequately careful due to their hasty operations. To alleviate such a constraint, it is recommended that the Indonesian Government take necessary actions so that the farmers, especially in the labor short areas such as outer islands, can earn profits from their use of agricultural machines through not only labor saving but also productivity increase.

This study was undertaken in cooperation of Japanese experts and Indonesian counterparts. The author wishes to express deep gratitude to them, especially the JICA team leader Mr. M. Irie; the design expert Mr. H. Takeshima; and the system analysis staff; Mr. Zaidir S., Miss A. Promosiana, Miss Trie L. D., Mr. Koesno H. and Mr. Djoko H.

References

1) Agency for Agricultural Research and Development, Directorate General for Food Crops of Indonesia and International Rice Research Institute: Consequences of small farm mechanization in Indonesia (1983).
2) Arai, T. et al.: Indonesian handbook. Jakarta Japan Club (1985) [In Japanese].
3) Central Bureau of Statistics of Indonesia: Agricultural machinery by province and districts 1985 (1986).
4) Central Bureau of Statistics of Indonesia: Statistical year book of Indonesia 1986 (1987).
5) Japan International Cooperation Agency: Study report on the post harvest losses in the Republic of Indonesia (1982).
6) Japan International Cooperation Agency: Agricultural extension in developing countries—Indonesia case (1987) [In Japanese].
7) Ministry of Agriculture of Indonesia: Country report and actions taken on the recommendations of 11th TAC sessions (1988).
8) Moran, P. B. et al.: Agricultural engineering training course. Text No. 27–39, IRRI (1984).
9) Soedjatmiko & Handaka: Agricultural engineering technology transfer—Indonesian case. *In* Proceedings of the International Symposium on Agricultural Mechanization and International Cooperation in High Technology Era, JSAM, 554–567 (1987).

(Received for publication, Feb. 8, 1989)