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THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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THE ECONOMICS OF TRACTOR OWNERSHIP AND USE IN SOUTH SULAWESI, INDONESIA

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By

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ECONOMIC EVALUATION OF TRACTOR OWNERSHIP AND UTILIZATION IN SOUTH SULAWESI, INDONESIA*

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ABSTRACT

The number of tractors in South Sulawesi, Indonesia has increased steadily from 25 units in 1974 to 1658 in 1981, although these are concentrated in only a few districts. The increased number and concentration of tractors in turn has created concern that expanded competition for the limited contract market would decrease tractor utilization below an economically viable level. The extent of the market for on-farm and custom services bears directly on the profitability of tractor ownership. This study analyzes the economic aspects of tractor ownership and utilization to provide guidelines for future policy in this area.

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*For more details, refer to Y, Maamun, Economic Analysis of Tractor Ownership and Utilization in South Sulawesi, Indonesia, Unpublished M. S. thesis UPLB, Philippines, 1983.

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INTRODUCTION

In most developing countries, national food policy aims to increase food production through use of improved technologies, including new crop varieties, irrigation and farm mechanization. The introduction of HYV brings concurrent requirements for improvement in cultural practices. The shorter growing season of the varieties make possible double or multiple cropping where sufficient water is available. Effective use of farm machinery allows faster land preparation and permits more efficient land use.

A substantial increase in the number of tractors on Indonesian farms has occurred during the past decade. Continued adoption of the machines has meant increased capital investment and higher cash costs resulting from operating these machines.

Since the early 1960's, mechanization of land preparation in Indonesia was introduced at several densely populated areas on Java and a less densely populated location on Sumatra and Sulawesi. The objective was an attempt to redress apparent shortages of man and animal power. Farmers used tractors mainly to augment available human and animal power during land preparation.

The number of tractors in South Sulawesi has increased steadily from 25 units in 1974 to 1658 in 1981, although these are concentrated in only a few districts. The increased number and concentration of tractors in South Sulawesi has created concern that expanded competition would decrease tractor utilization below an economically viable level.

The extent of the market for on-farm and custom services bears directly on the profitability of tractor ownership. This study, therefore, attempts to analyze the economic aspects of tractor ownership and utilization to provide guidelines for future policy in this area.

OBJECTIVES

The general aim of the study is to investigate the private and social justification for use of tractors in South Sulawesi. The specific objectives are:

1. To determine the pattern of tractor ownership and the costs, benefits and breakeven levels of tractor operation.

2. To assess the optimal number of tractors given assumed conditions of initial investment and operating costs, capacity and the cost of alternatives.

3. To determine factors affecting adoption and use of tractors.

4. To assess the social profitability of tractor ownership and use.

SAMPLING PROCEDURE

Data were gathered from the South Sulawesi site of the research project entitled "The Consequences of Small Rice Farm Mechanization in Asia". The data on tractor ownership and utilization consist of seasonal tractor earnings and the costs of operation.

Among the 23 districts in South Sulawesi, Pinrang and Sidrap districts were selected as research sites. Factors leading to the choice of this area were: 1) tractors have been used here for several years. The first machine was purchased in 1969 and the number reached 508 in 1979 representing 40% of the total tractors in South Sulawesi, 2) The districts are predominantly rice areas, with good irrigation and wide adoption of HYV of rice and other crops.

Based on the concentration of tractors, eight villages in the two districts were selected as sample villages. One hundred forty nine tractor owners in the eight villages were included. Respondents were grouped according to the year the tractor was purchased. Five stratification or vitantage groups consisting of 10 tractors each were randomly chosen, based on the year of purchase and operation from 1975 to 1979.
From the five vintage groups, four groups were further delineated for analysis. They were the 1975 and 1976 vintage groups, the average of the entire 50 tractor sample (1975-1979) and the 1982 (newest) group. The

observed receipts and expenses were employed in the case of the first three groups. For the 1982 group, we applied 1982 prices to the entire tractor group.

METHODOLOGY

Discounting technique were used to estimate: 1) the private (financial) profitability of tractor ownership and use, 2) the magnitude of changes in a specific variable necessary to reverse a decision among alternatives (sensitivity analysis) and, 3) the social profitability of mechanized land preparation.

Private or financial profitability of tractor ownership can be defined as:

$$\pi = TR - TC \qquad (1)$$

where:

π - profit

TR - is total annual revenues from tractor use

TC - is total annual costs consisting of fixed (FC) and variable (VC) components

Benefit Cost Analysis

To evaluate tractor profitability, the benefit cost ratios (BCR), Net Present Values (NPV), Internal Rates of Return (IRR) and Breakeven Points (BEP) were calculated for cash group.

BCR is defined as the ratio of the value of benefits to the value of costs, and is usually expressed as a discounted present value using the following formula:

$$BCR = \frac{\sum_{t=o}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=o}^{n} \frac{C_t}{(1+r)^t}} \begin{matrix} < \\ = \\ > \end{matrix} 1 \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

where:

B_t - are the benefits incurred in year t. These includes annual benefits of own and off-farm area cultivated and the salvage value in Rupiah.

C_t - are the costs incurred in year t. These include initial tractor cost and variable costs (for fuel, oil, operator/drivers and repairs and maintenance).

t - is index of the tth year

n - is the tractor life (year)

r - is the interest (discount) rate

NPV is defined as the net present value of cash inflows and outflows. A project is economically justified if the present value of inflow minus outflow is greater or equal to zero and unjustified otherwise. The NPV formula is:

$$NPV = \sum_{t=o}^{n} \frac{B_t}{(1+r)^t} - \sum_{t=o}^{n} \frac{C_t}{(1+r)^t} \begin{matrix} < \\ = \\ > \end{matrix} 0 \quad \ldots\ldots \quad (3)$$

where:

B_t, C_t, t, n and r are as well as previously defined.

<u>IRR</u> is defined as the interest rate at which the present value of cash inflows equals the present value of cash outflows or the discount rate at which the present value of cash inflows minus present value of cash outflow equals zero.

$$IRR = \sum_{t=o}^{n} \frac{B_t}{(1+r)^t} - \sum_{t=o}^{n} \frac{C_t}{(1+r)} = 0 \quad \ldots\ldots\ldots \quad (4)$$

where:

B_t, C_t, t, n and r as previously defined. The rule for interpolating the value of IRR lying between discount rates too high (r") on one side and too low (r') on the other is:

$$IRR = r' + (r'' - r') \left(\frac{NPV'}{NPV' - NPV''}\right) \quad \ldots\ldots\ldots\ldots \quad (4a)$$

where:

r' - is a lower discount rate

r" - is a higher discount rate

NPV'- is the net present value at the lower discount rate

NPV"- is the net present value at the higher discount rate.

BEP analysis indicates the level at which an investment neither incurs a loss nor produces a profit. For mechanization, it is defined as the use level at which the machine must be operated (hectares of land cultivated) to cover total annual costs. The BEP formula is:

$$\text{BEP (ha/yr)} = \frac{AFC}{X} + AVC \text{ or}$$

$$CR(X) = AFC + AVC(X)$$

Hence,

$$X = \frac{AFC}{(CR - AVC)} \quad \ldots\ldots\ldots\ldots \quad (5)$$

where:

CR - is the average custom rate (Rp/ha)

X - is the hectares area served to cover total annual cost at breakeven.

AFC - is average fixed cost (Rp/yr) as the total sum of depreciation and interest on capital investment.

AVC - is varaible costs (Rp/ha) as the total sum of operation costs as previously defined.

The assumptions of the analysis are as follows: 1) the expected economic life of the tractor is 5-years, 2) the final salvage value is placed at 10% of initial capital investment after 5-years and, 3) the capital discount rate on tractor investments is 12% per annum.

Sensitivity Analysis

In general, sensitivity analysis measures the relative magnitude of changes in one or more variables that will reverse a decision among alternatives. The variables of interest in the present analysis include: a) capacity utilization (ha/yr), b) purchase price (Rp), c) contract rate (Rp/ha) and d) economic life (yrs).

a) Sensitivity to capacity utilization. As annual use varies, the costs and revenue may also vary. The variables listed under group R_1 and C_2 to C_5 (Table 1) would vary in direct proportion to capacity utilization.

b) Sensitivity to initial purchase price. With the assumption that tractors cultivate a certain number of hectares each year, revenues (R_2) and fixed costs (C_1) will vary as the tractor price is varied. Other variables remain constant.

c) Sensitivity to the contract rate. The variables R_1, C_4 and C_5 will change as the contract rates changes.

d) Sensitivity to economic life, will affect the revenue (TR) and total cost (T_c).

Economics of Machinery Use

Evaluation of machinery ownership and use to determine the optimal tractor number for a finite area has important implications for mechanization policy and research (Jayasuriya et al, 1982). Consider that 1) the length of time required to complete a particular task in a given area is determined by the capacity and the number of machines available in the area, 2) the number of machines which can be operated at an economically viable level is determined by the cost structure and the prevailing custom rate, 3) the custom rate for a machine cannot be higher than the rate for alternative sources of power (human and animal), 4) custom rates for machines are low or maintained at a reduced level by the low cost of alternative power sources, 5)low custom hire rates require that machines operate over a larger area to be economically viable, hence the number of machines in a given area is low and, 6) when the number of machine in the area is low, the time taken to complete the task is longer.

The implication is that the timeliness advantages of mechanization will not be achieved in practice until the cost of alternative power rises. The minimum number of hectares of machine operation required to breakeven can be derived by calculating the maximum net present value (NPV) of the machine services over time.

$$\text{Max NPV} = \sum_{t=o}^{n} CR.A \frac{1}{(1+r)^t} + \frac{S}{(1+r)^t} - \sum_{t=o}^{n} VC.A \frac{1}{(1+r)^t} - P \quad \ldots . (6)$$

Breakeven area (A) can be obtained by substituting zero for NPV in (eq. 6) and solving for A.

$$A = (P - \frac{S}{(1+r)^t}) \cdot \sum_{t=o}^{n} \frac{1}{\frac{(CR-VC)}{(1+r)^t}} \quad \ldots\ldots\ldots\ldots (7)$$

where:

NPV - is the net present value

CR - is the custom rate (Rp/ha)

A - is the area served (ha/year)

S - is the salvage value

VC - is variable cost (Rp/ha)

P - is initial tractor price

n - is the number of year of tractor life

t - is index of the tth year

r - is the interest(discount) rate.

Social Profitability Analysis

From the individual farmer's point of view, market prices determine private (financial) profitability. Shadow prices are used in social (economic) analysis to measure the true value of goods to society. Both analyses are different, the financial analysis requires use of market prices and social analysis requires adoption of social prices. The difference between the prices are caused by: a) distortions in market prices make observed prices diverged from the real scarcity value of production factors to the economy and, b) market prices do not represent the socioeconomic policy and objectives of the government.

Based on these considerations, a proper assessment of the value of a project to the economy may call for adjustments in the market prices of goods, services or factors of production. If the prices do not coincide with their social prices "shadow pricing" should be employed. The shadow pricing exercise leads to estimation of the social benefits and costs in the presence of market distortions. It's defined as the increase in welfare resulting from any marginal change in the availability of commodities or factors of production (Van der Tak, 1981). Social prices are intended to reflect the true value of commodities or services and are used for various reasons such as price control and determination of comparative advantage.

In this study, shadow prices are derived for: a) tractor prices and services, b) diesel fuel and oil, c) labor and capital and, d) the exchange rate. The net social profitability concept (NSP) is used to measure the net gains (losses) associated with economic activities when

all commodity outputs produced and material inputs employed are evaluated at their social opportunity cost (through the use of shadow prices). The NSP formula is:

$$NSP = \sum_{t=o}^{n} O_{ij} S_o - \sum_{t=o}^{n} I_{ij} S_i + E_j \quad \ldots\ldots\ldots\ldots \quad (8)$$

where:

NSP - is net social profitability

O_{ij} - is the quantity of the ith output produced by the jth activity

S_o - is the quantity of the ith input used by the jth activity

S_i - is the shadow price of the ith input

E_j - is a measure of the net external benefits or costs imparted by the jth activity to the rest of the domestic economy.

Output of tractor ownership is the earnings from cultivation activities on the owner's farm and off-farm. Factors of production (inputs) used are the tractor, labor, capital, diesel and oil. Component E_j, which is the net benefit or cost to the rest of the economy, is assumed to be zero. The social analysis of tractors is derived from the utilization pattern of the average entire tractor group using 1979 prices.

RESULTS

The main factor affecting increased adoption of 4-wheel mini tractors in the study area was increased demand for custom work. Figures 1 and 2 show that tractors have become very popular, as indicated by their increased utilization for land preparation. The household census and survey data (1979) showed that farmers have shifted from using manual and/or animal power to combinations of manual + tractor (MT) and manual + animal + tractor (MAT).

Increased demand for tractor loans from the government banks for purchases of tractor increased markedly up to 1979. The low interest rate (12%) was very low compared to 20% to 30% for other lending agencies. This implies the availability of capital at low interest rates constitutes a strong incentive for tractorization and has been a major inducement to invest in tractors.

Tractor owners are usually farmers or traders, have greater assets and are more educated compared than non-owners or nonmechanized farmers in the same area (Consequences Survey, 1979). To cultivate their own land was the most common reason (44%) given for the purchase of a tractor. The benefits associated with tractor ownership were the potential for timely planting (29%), followed by better land preparation (25%) and reduced hired labor requirements (25%). Only 10% believed the tractor increased yield or reduced drudgery.

For the fifty sample tractors, 70 operators/drivers were employed. Most had only 1 to 2 years of experience in tractor driving, and were without any formal training in tractor use. The major reasons for being

a tractor driver was to obtain a higher wage (44%). Most were engaged in agriculture (88%).

The most frequent tractor breakdowns over the life of the machine were transmissions (34%), implements (especially the rotary blades (29%)) and the engine (piston and associate components - 25%). Frequent damage to the transmission was due to stopping and starting under load. High implement damage, especially to rotary-blades resulted from the low quality of the replacement parts. Engine damage was due to late oil changes and continuous operation beyond the recommended hours. The factors associated with tractor breakdowns were poor maintenance by the driver (34%), driver's inexperience (22%), frequent turnover of drivers (19%), distance from repairshop (16%) and low quality of equipment (9%). Consequently, it appears tractor breakdowns could be reduced through better driver training and supervision. Delays in repairs were associated with spare parts availability and the long distances to the repairshop.

Figure 3 shows the tractor utilization for own and off-farm or custom land preparation. The total area served was larger in the wet than in the dry season and the annual hectarage shows a decline since the initial year of operation. This is due to declining capacity utilization and the increasing number of tractors in the area which made competition keen. Own farm area served (13%) is smaller than the area of custom work (87%), (Figure 4).

Table 2 indicates the profitability of tractor ownership and use. None of the four groups were profitable, as indicated by BCRs less than

one, a negative NPV and an IRR less than the opportunity cost of capital with the exception of the 1982 group and then only if the official custom rate is used. The breakeven analysis shows all tractor groups were under utilized. At existing custom rates and capacity utilization, the minimum BEP was not achieved. Low custom rates were charged, because low cost alternatives (manual and animal) were available. The BEP can only be attained by maintaining the official custom rate or by increasing annual utilization (area served).

A sensitivity analysis shows that changes in the contract rates results in large changes in the BCR, NPV and IRR. A 10% increase in the contract rate will increase the BCR, NPV and IRR by 10, 73 and 23 percent respectively. A reduction in the contract rate has a very adverse impact on the BCR, NPV and IRR (Table 3). The NPV in particular is highly sensitive to capacity utilization and/or economic life.

The optimal tractor number for a finite area is a function of tractor utilization, the custom rate and the level of subsidy. For example, if capital is subsidized at custom rate of Rp 16,200/ha, 67 ha/year or 33.5 ha/season are required to breakeven (Table 4). For a 100 ha area, the optimal tractor number is 30 units. With this tractor population, it requires 75 days per season to complete land preparation with an 8 hour work day and 2.5 days per hectare. The custom rate would need to be Rp 20,000/ha to make it worthwhile for the tractors to complete land preparation within a two month period. Reducing the interval for land preparation requires an increase in the number of tractors and the custom rate. The tractor custom rate will not, however,

be higher than alternative manual and animal power since farmers (customers) can switch to a competing power source.

A higher custom rate must be charged under unsubsidized capital cost to make tractor ownership worthwhile. It was clear that the subsidized cost of capital had a substantial impact on investments in tractors and there is little or no possibility of mini-tractors being economical without subsidies.

The effects of subsidies was further explored through social profitability analysis. Table 5 shows the profitability using a private and social cost-benefit comparison. Losses were incurred by tractor owners using private prices. Higher losses were incurred using 1979 shadow prices. Subsidies on the cost of capital and fuel lower the private cost but increase the cost to society. The private costs, including depreciation, interest, maintenance and operation were about Rp 23,000/ha or Rp 5000 lower than the social cost. Thus the net benefit of tractors to individuals is clearly higher than to society.

SUMMARY

It has been shown in the study that at prevailing prices, four-wheel mini tractors are unlikely to generate a positive return on investment. Investments in tractors are not financially sound, and the situation will become worse if tractor numbers increase and are concentrated in a limited area.

Several remedial measures can be suggested. First, increase the area per tractor served or capacity utilization by limiting the

concentration of tractors. The economics of tractor use indicate that given a finite area, a high tractor population provides the potential for a short turnaround period for land preparation. Secondly, an inventory of all available power sources (manual and animal) used for land preparation should be made before introducing additional power. Third, official custom rates are misleading as a basis for computing costs and returns. An increase in the custom rate for tractors does not make economic sense, since alternative power sources are available at equal or lower cost. Customers can shift from using tractors if they feel tractor custom rates are unreasonably high. Another alternative is make tractors worthwhile by increasing utilization for transportation and cultivating not only irrigated lowland but also rainfed dryland field.

Lastly, the government can give serious consideration to use of domestically produced machinery which increases the domestic value added, are more serviceable, easier to operate and have a lower initial investment cost.

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Table 1. Revenues, costs and profits for tractors.

No.	Item		
1.a.	Revenue = area served (ha) x custom rate (Rp/ha)	=	R_1
b.	Salvage value = 10 percent of initial cost	=	R_2
			TR
2.	Expenses		
a.	Fixed cost (initial cost)	=	C_1
b.	Variable cost		
	Fuel = liter/ha x price (Rp/l) x area served (ha/yr)	=	C_2
	Oil = liter/ha x price (Rp/l) x area served (ha/yr)	=	C_3
	Driver = ave. wage (Rp/ha) x area served (ha/yr)	=	C_4
	Repair & maintenance = ave. cost (Rp/ha) x area served (ha/yr)	=	C_5
			TC
3.	Profit (net benefit) π = TR - TC		

Table 2. Profitability analysis: BCR, NPV, IRR and BEP of 4-wheel mini tractors, South Sulawesi 1975-1982.

	1975	1976	Entire group 75-79		1982 prices[a]	
			5 yr	6 yr	5 yr	6 yr
No. of observations	10	10	150		150	
1. BCR (12% disc.)	0.81	0.97	0.79	0.81	1.15 (0.93)	1.24 (0.99)
2. NPV (12%, Rp 000)	-539	-87.6	-743	-700	1157 (-523)	1893 (- 24)
3. IRR (12%)	<1	10.5	<1		18.4 (7.9)	20.0 (11.9)
4. Area served (ha)						
Breakeven	60.37	55.19	62.79	54.64	38.07 (55.25)	33.12 (48.07)
Actual	46.38	54.24	51.70		51.70	
5. Custom rate (Rp)						
Breakeven	18,141	16,750	18,300	16,752	37,371	34,603
Actual	15,439	16,586	16,194		45,000 (36,000)	

[a]Figures in parentheses refer to a 20% custom rate reduction.

Table 3. Sensitivity analysis: Elasticities of BCR, NPV, and IRR with respect to stated parameters using 1982 prices for ave. of entire group.

Parameter	BCR[a]	NPV[a]	IRR
1. Capacity utilization	0.052	0.469	0.004
2. Initial tractor price	-0.052	-0.367	-0.085
3. Contract rate[b]	0.096 (-0.191)	0.726 (-1.452)	0.229 (-0.656)
4. Interest (disc.) rate[c]	0.226	-1.629	-
5. Economic life	0.078	0.636	0.154 (-0.13)[d]
6. Economic life and capital util.	0.048	0.327	-0.023
7. Economic life and price	-0.048	-0.224	-0.026
8. Economic life and contract rate	0.097	0.507	0.236

Assume a 10% increase in parameters 1,2,3 and one year of economic life in 5,6,7,8.

[a]Discount rate at 12%

[b]A 20% custom rate reduction in parentheses

[c]A 150% increase in interest rate from 12% to 30%

[d]Elasticitiy of economic life to breakeven area

The elasticities are defined as dY/dX and indicate the % change of the Y coefficient to a 10% change (increase) in the relevant parameter X.

Table 4. Economics of machinery use, with given area and existing costs of operation.

	Ave. entire group[a]			1982 prices[b]			
	1	2	3	1	2	3	4
Custom rate (Rp.000/ha)	16.2	20 (25)	36	36	40 (50)	45	50
Operating level for BE							
days/yr	168 (248)	130 (130)	55 (83)	148 (218)	123 (128)	103 (150)	88
ha/machine/yr	67 (99)	48 (52)	22 (33)	59 (87)	49 (51)	41 (60)	35
Operating level on 1000 ha at BE							
Machine/1000 ha	30 (20)	42 (3[illegible])	91 (61)	34 (23)	41 (39)	49 (33)	57
Days to complete operations	75 (124)	60 (65)	28 (41)	74 (109)	61 (64)	51 (75)	44

[a]Tractor price Rp. 2,516,000/unit.

[b]Tractor price Rp. 4,500,000/unit

Figures in parentheses refer to unsubsidized capital cost (30% r).

Table 5. Private and social cost-benefit comparison 1979/80.

	Private cost	Social cost
Area served (ha/yr)	52	52
Custom rate (Rp/ha)	19,000	19,000
Tractor price (Rp/unit)	3,300,000	2,884,980
Fixed cost (Rp/yr)		
Depreciation (5 yr)	11,423 (50)	9,986 (36)
Interest on capital	4,188 (18)	6,103 (22)
Variable cost		
Fuel (l/ha)	36	36
(Rp/l)	45	178
(Rp/ha)	1,620 (7)	6,408 (23)
Oil (l/ha)	0.95	0.95
(Rp/l)	500	496
(Rp/ha)	475 (2)	471 (2)
Driver (Rp/ha)	2,850 (13)	2,850 (10)
R/M (Rp/ha)	2,375 (10)	2,332 (8)
Total cost	22,871 (100)	28,150 (100)
Net benefit	-3,871	-9,150
BCR	0.83	0.67

Figures in parentheses refer to percent of the total cost.

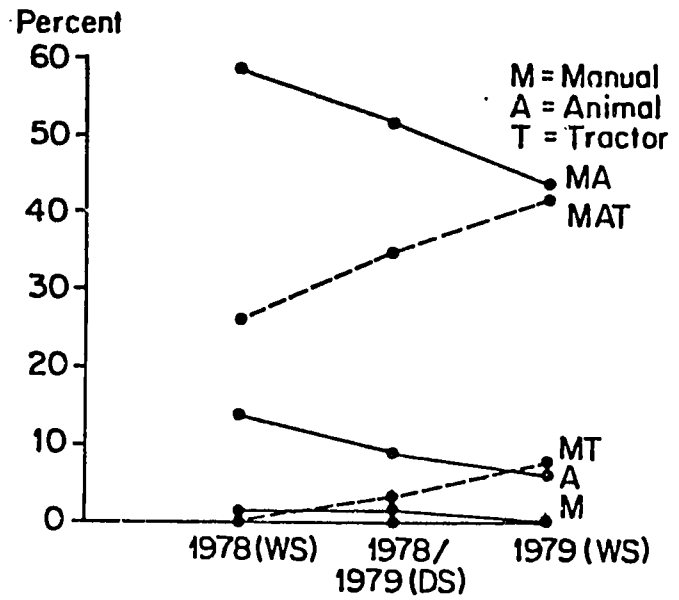

Fig. 1. Power types for land preparation (Household Census of 1,367 farms) in Pinrang and Sidrap Districts, South Sulawesi, Indonesia.

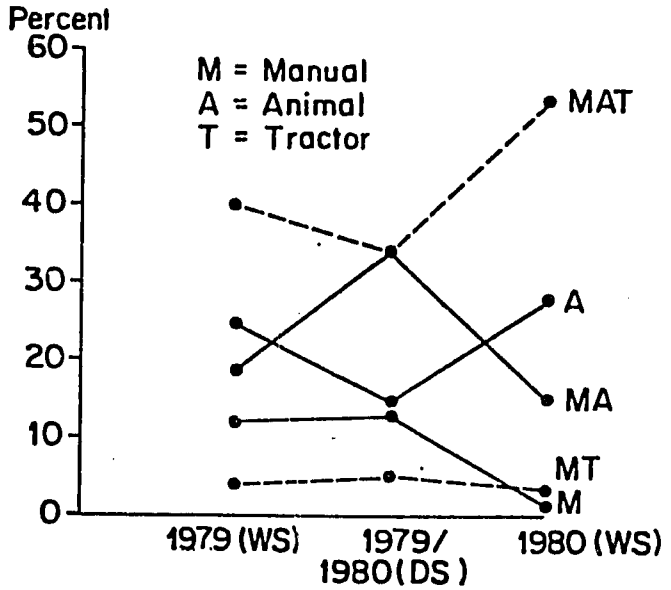

Fig. 2. Power types for land preparation (Survey of 260 farms) in Pinrang and Sidrap, South Sulawesi, Indonesia.

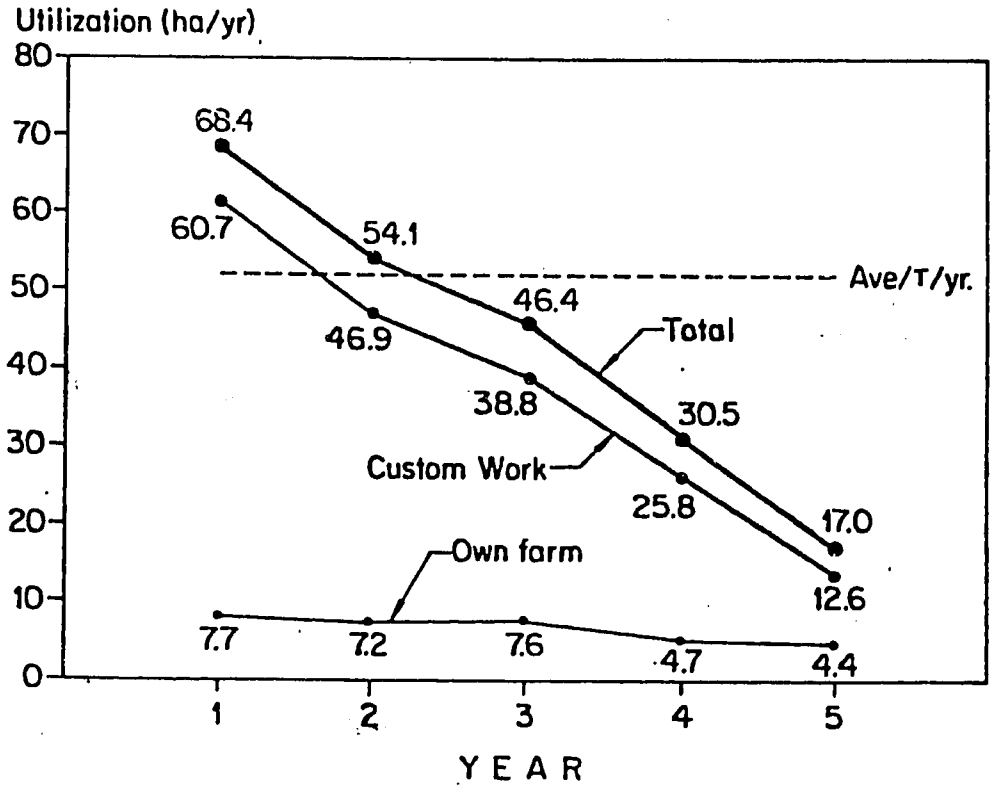

Fig. 3. Four-wheel mini tractor utilization in Pinrang and Sidrap districts, South Sulawesi, Indonesia.

4-WHEEL MINI TRACTOR

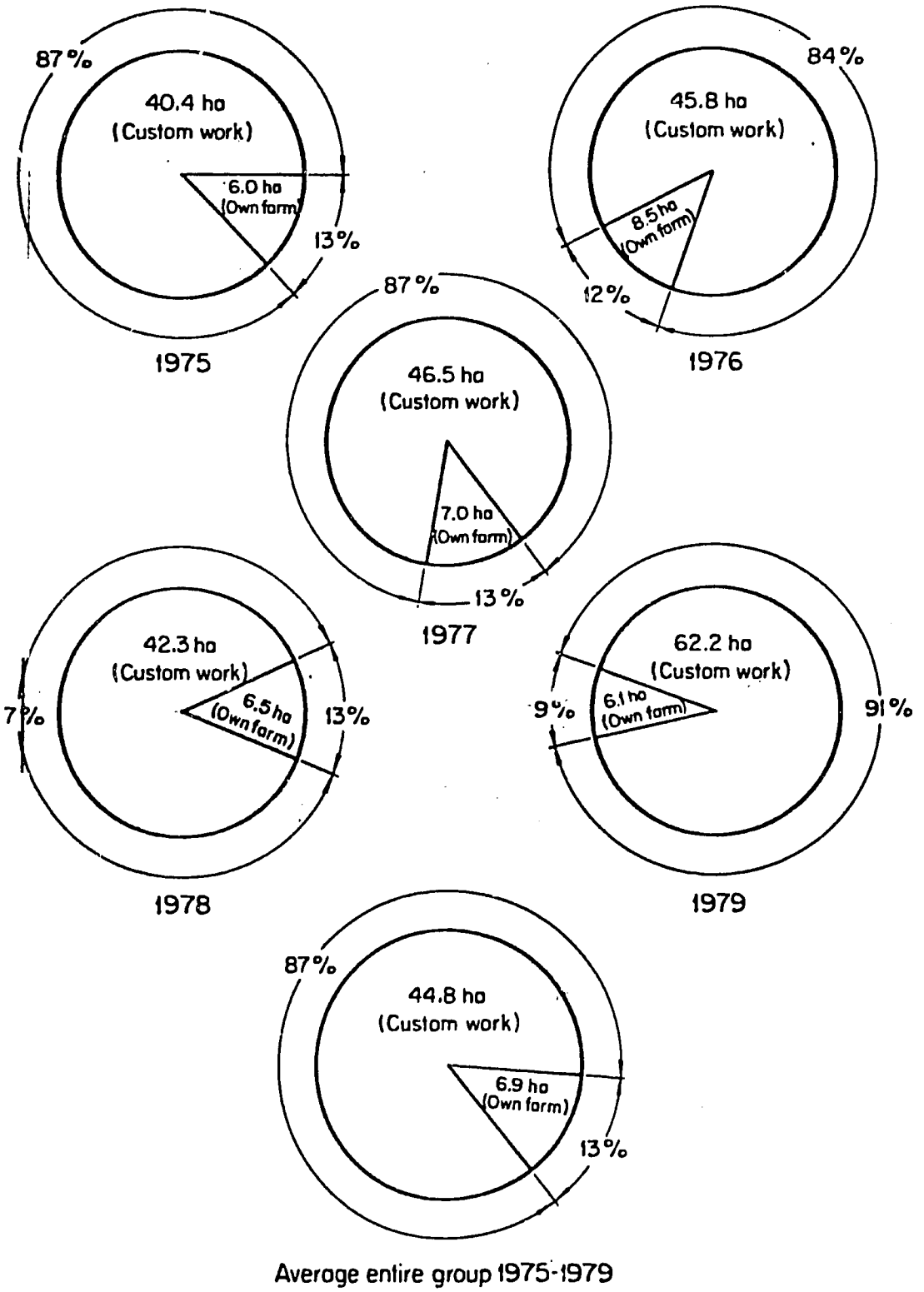

Fig. 4. Comparative utilization by tractor vintage group and location of activity, 1975-1979, South Sulawesi, Indonesia.