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THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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RESULTS OF A COMPARATIVE EVALUATION OF FOUR-WHEEL, TWO-WHEEL AND TRADITIONAL LAND PREPARATION METHODS IN LUWU SOUTH SULAWESI, INDONESIA

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LUWU ECONOMIC REPORT

LUWU MECHANIZATION SUBPROJECT*

The Luwu project is located in Sulawesi, one of the four largest islands comprising the Indonesian archipelago. The area is currently the target for intensive integrated development activity including infrastructure and institutional development and technological transfer and adaptation.

A small farm mechanization subproject has been undertaken as a component of this comprehensive program to increase and improve the agricultural potential area. While there is some diversity in cropping patterns, lowland rice is the most important single crop. In contrast to Java, land is abundant on Sulawesi and supports a lower population density. The stock of animal power is also limited. To perm.· crop intensification and more efficient use of available water supplies, supplemental power for tillage in the form of small machinery has been introduced. Small Japanese 12 horsepower (hp), 4-wheel drive "mini" tractors were first introduced to the area in

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1977. While coverage has been constrained by the limited number of machines available, there has been interest in expanding their availability and utilization. Since 1980, there have been three factors which have mitigated against further proliferation in the number of imported machines. First, the initial investment cost for tractors has increased 30 to 40% during the period, which clearly puts them out of reach of most farmers without access to special credit programs. A second factor has been the complexity of the machines and their susceptibility to frequent breakdowns. As is noted later in the report, lack of spare parts and the associated high maintenance costs have resulted in rising operating costs and inability to employ the machines near their potential field capacity. A third factor has been the introduction of a low-cost alternative, the 2-wheel walking tractor. Based on a simple design originating from the International Rice Research Institute, this machine can be fabricated in Indonesia and sold and serviced by onsite machine shops equipped with only rudimentary tools and skills. Most parts can be produced locally or purchased through hardware supply companies. The low initial cost puts the machine within the investment potential of the small farmer.

To test the efficacy and comparative economics of the 2-wheel tractor with other alternatives available in the Luwu area, ten basic 2-wheel units were acquired in 1981. Six machines equipped with diesel engines, harrows, moldboard plows, puddling wheels and heavy

duty trailers were distributed to selected farmers. The remaining four machines were retained as demonstration units by the R E C. Each of the farmers/operators was trained in maintenance and handling procedures.

The Survey Design

A small team of field enumerators were hired to monitor use of the machines. Records were maintained for a purposively selected sample consisting of 6 farmer-cooperators managing the 2-wheel tractors plus an additional seven 4-wheel tractor owners, 10 tractor users and 10 farmers using traditional techniques of land preparation. The objectives of the monitoring activity are:

1. To assess the economic viability of mechanical land preparation in the Luwu project area.

2. To compare the technical and economic characteristics of alternative land preparation systems (both mechanized and non-mechanized).

3. To evaluate the technical support services required for each system.

4. To investigate the efficacy of private versus joint (cooperative) ownership and use of land preparation equipment.

5. To determine the potential impact of mechanized land preparation on employment, income and crop production in the Luwu project area.

Results and Discussion

Table 1 contains a demographic and socio-economic description of the 33 farmer respondents included in the study. The 2-wheel tractor owning group had the smallest average farm size (0.80 ha), while the 4-wheel tractor group was the largest (2.36 ha). While the tractor hiring group [1], (0.86 ha) and the traditional farms (1.09 ha) were intermediate in this size grouping.

None of the four groups varied significantly from others in educational attainment or family size. The 2-wheel tractor owners were the youngest among the groups at 27 years on the average, and had the fewest years in farming (6 years). Traditional farmers were the oldest (45 years old), and also had the longest experience in farming (22 years) among the farm groups. The latter statistic reflects the relatively recent settlement of the area and the continuing immigration of settlers during the past 2 decades.

The farm characteristics for each category are summarized in Table 2. The average land value for 2-wheel tractor owning farms was Rp 1,153,000/ha while the 4-wheel tractor using farms owned the most valuable land (Rp 2,427,000/ha).

The lowland value for two-wheel tractor owners is partially attributed to the lower productivity of these farms as reflected in the different soil qualities shown in Table 2. In the Luwu area, standard land values are as follows: first class land is Rp. 3 million/ha, second class, is Rp 2 million/ha and third class is valued at Rp 1 million/ha.

Changes in the farm and farming practices. All farmers planted IR-42. Two-wheel tractor owners also planted IR-48 while C4-63 was grown by both 2- and 4-wheel tractor owners. Straight row planting was common to all respondents (Table 3).

Some changes in machine use and farming practices which took place during the period between adoption of mechanization and the survey year are summarized in Table 4. Among the respondents within the three tractor using groups, i.e., 2-wheel tractor owners, 4-wheel tractor owners, and tractor hirers, all had used the tractor continuously after initial introduction on their farms. None of the two-wheel tractor owning farms had previously used tractors. Four-wheel tractor users began to mechanize in 1981. The tractor hirer group had first used mechanization in 1977. The most recent being in 1982.

Some of the most important reasons given for using tractors were (1) quality tillage, (2) timeliness in planting, and (3) use of the tractor permits the farmer to do other jobs. Minor reasons cited were (1) easier method of land preparation, (2) tractor use less costly, (3) can be used for transport, and (4) enables expansion of cultivated area. No respondents however, indicated a change in cropping pattern resulting from mechanization. A majority felt the machine provided better quality tillage than traditional techniques. There is also no evidence to support a tillage effect on the yields obtained from mechanized contrasted to non-mechanized farms. Improvements in the

water supply system, such as installation of water gates was implemented in 1978 and 1979.

Table 5 lists the factors considered in the farmer's tractor purchase decision. A majority of the respondents indicated buying a 4-wheel tractor was a family decision. Two-wheel tractors were initially offered by the FCC Bone-Bone office on trial basis.

Of the 10 respondents under the traditional farm category, 8 reported having financial liabilities, while all respondents in three mechanized groups had debt obligations. Most loans were for 6 months or less except those belonging to the 4-wheel tractor owning group, wherein 5 of the 7 respondents also reported loan maturities of up to 6 years and one among the 2-wheel tractor owners had a loan of up to 7 years.

The most commonly cited collateral used for loans were land titles (Table 6). Some also used buildings as security. All borrowed money for seasonal farm expenses. Most loans were provided by government programs through banks. A few cited friends and relatives as another source. Interest rates charged were all 12 % per year. The 4-wheel tractor owners had the highest total indebtedness per farm of Rp 589,557 while the other three groups had loans averaging Rp 20,200 for 2-wheel tractor owners[2], Rp 22,390 for the tractor hirers and Rp 23,450 for traditional farms.

All farmers in all four categories owned draft animals such as oxen and/or cattle: 27 by traditonal farmers, 10 by 2-wheel tractor owners, 8 by the 4-wheel tractor group, and 25 by the tractor hiring

group. Each also owned implements such as plows and harrows (Table 7).

Table 7a shows the types and number of farm implements owned by the respondents in each category.

Among the more important ones are ox plow, harrow, rotavator and sprayers. For traditional farms, the highest average investments on tools and implements were those for sprayers and ox plows. The same was true for tractor hiring farms and for 2-wheel and 4-wheel tractor owning farms. Each of the 4-wheel tractor owning farms had a rotavator.

Material inputs. To compare the farming practices of the respondents by category, farm inputs such as seeds, fertilizers and chemicals were compared.

Table 8 shows the degree of modern technology by the farmer respondents within each group. No distinctive pattern could, however, be deduced from the results.

Both the tractor hiring farms and the 2-wheel tractor owners used the largest amounts of seeds per hectare for both wet and dry seasons while the 4-wheel tractor owning farms used the least amount. This was also true in terms of amount spent for seeds. Price per kilogram of seeds used during the wet season were generally lower averaging to Rp 120/kg while seeds used during the dry season costed an average of Rp 237/kg. Farmers seemed to prefer higher quality seeds during the

dry season (as reflected in its unit price) than during the wet season.

Fertilizer use was highest among tractor hirers and traditional farmers during the wet season and lowest among the 2-wheel tractor owners. However, during the dry season, 4-wheel tractor owning farms applied the least amount while the other groups applied it more generously.

Pest control chemicals which include insecticides, weedicides/herbicices and rodenticides were most generously used on the traditional farms for the wet season but used least on the 4-wheel tractor owning farms. The amounts applied during the dry season crop were not completely recorded and therefore could not give any definite picture. However, the 4-wheel tractor owners had so far spent the least amount of chemicals per hectare.

Production and disposal of products. During the wet season, the highest average total production was reported by the tractor hirers at 2.9 tons/ha while the 2-wheel tractor owners reported the lowest yields at 2.3 tons/ha (Table 9). The very low yield of the latter is attributed to the poor soil quality which even higher seeding rates could not offset. The relatively low level of fertilizer used by this group is also another factor contributing to low yields. All farming groups paid 1/7th of the gross harvest and retained about 50% for home consumption, seed requirements, and future sales. Tractor hiring farms sold the largest amount of paddy, averaging 1.16

tons per ha. Traditional farms and 2-wheel tractor owning farms marketed only .44 and .43 tons per ha., respectively. They also retained a smaller portion of the total crop for other purposes. The average price of paddy was Rp 100 per kilogram.

Data for the dry season crop were not available.

Labor and Power Inputs

Records of labor and power inputs were maintained for each operation from seedbed preparation through harvest for the wet season. However, for the dry season crop, the information recorded were only up to some fertilizer and chemical applications. Records on other farm activities were not available.

Human labor hours were also classified by source between family and hired, the latter including exchange labor.

Family vs. hired labor input. Table 10 provides a disaggregation of total labor by different farm operations and source. The 4-wheel tractor farms used less total and hired labor than the other categories during the wet season.

A substantial reduction is evident in the land preparation activities--- plowing, harrowing, levelling and puddling. The large difference in labor required for transplanting is not explainable with the data currently available. However, the amount of seeds used per hectare by the 4-wheel tractor farmers which was the least among the groups may partly explain this discrepancy. There is no notable difference between total labor use by either traditional or tractor hiring farmers, although those contracting for custom service employ a

higher proportion of hired labor than other categories. The 2-wheel tractor group used somewhat less total labor than either the traditional or the tractor hiring group.[3]

Among the three groups, the tractor hiring farmers had the highest percentage of hired labor during both wet and dry seasons. Four-wheel tractor owners had the lowest percentage hired labor during the wet season but it was the traditional farmer group that had the least in the dry season. Plowing and harrowing operations were both performed more by the farmer and his family than hired laborers (Table 10). Levelling and puddling operations, however, which are generally done using draft animals do employ hired labor. This is explained by the farmers' intention to finish the operation on time considering the animals' field capacity. Hired labor was predominantly used for transplanting on all farm categories for both wet and dry seasons. For harvesting/threshing/cleaning operations during the dry season, hired labor was also utilized by all farm groups.

In Table 11, power inputs are segmented by source into 2 major categories: (1) seed and seedbed preparation and (2) transplanting. Harvesting and other post-harvest operations are not included here since the information are not available at present. Tasks involving animal and tractor power are seedbed preparation, plowing, harrowing levelling and puddling. Only one respondent reported transporting paddy from the field.

Sources of power inputs. Table 11 also shows the source of power for land preparation and other farm activities. Both the 2- and

4-wheel tractor owning farms had relatively lower manpower requirements/ha for land preparation than the other two farm categories. During the wet season, four-wheel tractor owning farms completed seed and seedbed preparation and land preparation activities using 34 man-hours, 10 animal-hours and 16 tractor-hours/hectare. Two-wheel tractor owners used 92 man-hours, 14 animal-hours and 48 tractor-hours/hectare for the same operations. These labor hours were reduced during the dry season for both farm categories. Four-wheel tractors owning farms used 29 man-hours, 26 animal-hours, and 13.4 tractor hours per hectare, while two-wheel tractor owning farms utilized 49 man-hours, 19 animal-hours, and 34 tractor-hours for seed and seedbed preparation and land preparation activities. Traditional farms had the highest man and animal hours/ha for similar operations, followed by tractor hiring farms. The total man-power inputs needed to complete all farm operations did not differ appreciably for the traditional farm, 2-wheel tractor owning farms and the tractor hiring farms. Four-wheel tractor farms had the lowest total manpower requirements.

Tractor utilization. Two- and four-wheel tractor utilization for the wet season are summarized in Figs. 1 and 2. Both tractor types were used predominantly for custom work. The average area serviced by each of the six 2-wheel tractors was 23.4 hectares during the 1981-82 wet season, and 18.96 hectares during the dry season.[4] Twenty one hectares were custom services and the remaining 2.4 hectares were on their own farms during the wet season. Similarly, the seven 4-wheel

tractors contracted an average of 14 hectares and prepared 2.4 hectares on their own farms or a total of 16.4 hectares for the same season. Such data were not available for the dry season operation. One possible reason for the relatively low average utilization of the 4-wheel tractors is the difficulty these machines have in accessing interior fields and crossing irrigation channels. Figure 2 summarizes the information from Figure 1 and also shows the percent utilization by location of activity, i.e. custom work and own farm. No significant difference was noted between the two tractor types with regard to percent distribution of activities by location.

Repairs and maintenance. Repairs and maintenance expenses for the 2-wheel tractors were minor since the machines are all new. Costs were mainly for minor parts such as belts. Thus, the average repair and maintenance cost for each tractor was a low Rp 259/ha for the wet season and Rp 478/ha for the dry season on an average of Rp 357/ha per season.

In contrast, the mini tractors with an average age of 2.6 years, had several major breakdowns. Table 12 provides the seasonal repair and maintenance costs for each tractor from the year of purchase up to 1981-82 (the survey year). Average repair and maintenance costs for each tractor per season are summarized at the bottom of the table. Also shown is the average area serviced since the year of purchase. The average total repair and maintenance (R & M) cost per hectare are calculatred from these figures.

Figure 3 presents the relationship of R & M costs to tractor age. This figure illustrates that as tractors age, annual repair and maintenance costs rise steeply.

Cost Analysis of Two-wheel and Four-wheel Tractors

A profitability analysis of the two- and four-wheel tractors is presented in Table 13 giving financial benefits from owning these machines.

Two-wheel tractors were estimated to normally have a 4-year life (8 seasons) and 4-wheel tractors had 6 years (or 12 seasons). Initial investment costs were calculated at Rp 1.6 million for the 6-hp power tiller. Two initial investment levels are given for 4-wheel tractors, Rp 3.2 million for units purchased in 1977 and Rp. 4.6 million for those acquired in 1981. Annual fixed costs consisted of seasonal depreciation and the interest on capital investment. Depreciation was computed using a straight line method with the salvage value of the machine estimated at 10% of initial cost. Interest on average capital investment was 12% per annum.

Variable costs consisted of fuel and oil, repair and maintenance costs and the driver's fee. Fuel consumption was calculated at 15.63 l/ha for 2-wheel tractors and 35 l/ha for 4-wheel tractors priced at Rp 125/l. The driver's fee was computed at Rp 3500/ha for plowing and Rp 2000/ha for harrowing by 2-wheel tractors. For four-wheel tractors, 15.5% of gross income was paid to the drivers.

Although the initial cost of two-wheel tractor was only half that of the 4-wheel tractor, the seasonal fixed costs for each were not proportionately different because of the assumed differences in useful life (4 years for 2-wheel and 6 years for 4-wheel tractors).

Average repair and maintenance costs for the 2-wheel tractors were relatively low compared to the 4-wheel units. The reasons could be the older age of the latter, the age of the 4-wheel machines was 2.6 years on the average. Two-wheel tractors were all less than one year old. There are also lesser number of moving parts and therefore less wear and tear.

Total variable cost per hectare for the 2-wheel tractor during the wet season was Rp 5023/ha which is considerably lower than the 4-wheel tractor at Rp 14,104. With an average utilization of 23.32 ha (total area including 1 plowing and 2 harrowings) for 2-wheel and 16.4 ha (doing rotavation) for 4-wheel tractors, the total costs per season were computed. Contract rate charged per hectare by the 4-wheel tractor owners is Rp 40,000, that is for rotavation, while the 2-wheel tractor owners charged Rp 25,000/ha for plowing, Rp 10,000/ha for 1st harrowing, and Rp 5,000/ha for 2nd harrowing. Adding the three operations, the total contract rate/ha wold also be Rp 40,000/ha. The average value derived from its actual utilization gives a contract rate of Rp 20,000/ha per operation. Net benefits were derived from these values, giving the 2-wheel tractor an average benefit of Rp 77,814 and 4-wheel tractors, Rp 77,400. The payback period for the 2-wheel tractor would be about 6.2 seasons while the 4-wheel tractor

requires 10.1 seasons in order to recover the initial investment of Rp 3.2 million. Machines purchased for Rp 4.6 million needs 17.0 seasons to make its investment economically viable.

Break-even points for 2-wheel tractors were computed at 15.8 ha for wet season and 16.0 ha for dry season, while for 4-wheel tractors, the values were 13.4 and 19.2 ha both for wet season.[5] Benefit-cost ratios were also calculated. Two-wheel tractors had a ratio of 1.2 during the wet season and 1.1 during the dry season. Four-wheel tractors had a ratio of 1.1 at Rp 3.2 million investment level but got less than 1.0 at 1981 price of Rp 4.6 million.

Regarding the dry season utilization, only the 2-wheel tractors had available data and therefore, no cost analysis could be done on the 4-wheel tractors for the said season.

Two-wheel tractors were utilized less during the dry season doing only 18.96 hectares. The total variable costs per hectare was greater than that of wet season total because of higher repair and maintenance costs. At this rate of utilization, the benefit-cost ratio was slightly lower (1.1) than that of the wet season.

If the current contract rate of Rp 40,000/ha were increased to Rp 50,000, the net income to be derived from using a 4-wheel tractor at an investment of Rp 4.6 million would be positive, from negative Rp 73,600 to Rp 64,558. The break-even point or area operated per season required to recover the capital invested for 4-wheel tractor type would also be lowered from 13.4 ha to 9.6 ha/season. However, decreasing the present contract rate/ha to Rp 30,000 raised the

break-even levels. The 2-wheel tractor unit is, however, less sensitive to this reduction than the mini-tractors and would still prove profitable at current seasonal utilization levels (23.3 ha) for wet and 18.96 ha for dry seasons.

Machine owners have the option of either increasing their contract rate per ha or seasonal utilization. Competition from both traditional and other mechanical technologies will be the determining factor in establishing the final equilibrium.

SUMMARY AND RESULTS

With only a single season of complete field data available, the impact of an innovation cannot be assessed comprehensively. The preliminary findings from use of the 2-wheel tractors are, however, encouraging:

1) During the 1981-82 wet season, all six 2-wheel tractors included in the project have been used intensively and were operated near their effective field capacity.

2) Repair and maintenance problems have been minimal during this early phase of the project, reflecting the new condition of the equipment, the value of operator training and the availability of adequate maintenance services.

3) The machines are clearly a profitable investment for those farmers managing them.

4) The 2-wheel tractor shows a clear advantage over both traditional methods and the 4-wheel mini-tractors in land preparation.

5) Major limitations of the 4-wheel tractors are (a) high initial cost, (b) high cost and lack of spare parts, (c) limited mobility and access to interior fields.

6) The impact on labor requirements has been a reduction in family and an increase in hired labor employed for land preparation. Total labor requirements for rice production are, however, only slightly less than for farms using traditional land preparation techniques.

7) There have been no perceived yield or cropping intensity effects for those owning or using the tractors.

8) There exists a large latent demand for mechanical land preparation in the Luwu project if these services can be made available at or near current contract rates (Rp 40,000/ha).

RECOMMENDED SUPPLEMENTARY ACTIVITIES

During the next phase of the project it will be necessary to continue to monitor the machines and farmers included in the initial phase. As a supplement, we suggest the following activities:

1) Gather and/or retain records on the use and performance of four- and two-wheel tractors owned by the cooperative. The contrast between institutional and individual ownership and management may provide some insights regarding the most efficient mechanism for making tractor services available to small farmers.

2) Carefully assess potential demand patterns for 2-wheel tractors in the project area. Provide a normative analysis of the

market profile considering sensitivity to (a) changes in the initial cost of the machines, (b) changes in the cost of fuel, (c) changes in contract rates and (d) availability of credit at alternative interest rates and maturity dates.

FOOTNOTES

[1] Composed of farmers hiring both 2- and 4-wheel tractors.

[2] Does not include financial obligation to acquire the machine after the first year of use. This condition is an optional choice under the agreement entered into at the time the 2-wheel machines were initially distributed.

[3] The finding that the harvesting, threshing, cleaning operations utilize entired hired labor may have some implications for mechanization of these activities in the future.

[4] This figure represents the entire area cultivated, and includes, plowing, harrowing, puddling and levelling operations. It is not directly comparable with the area covered by 4-wheel tractors which normally utilize a rotary tiller and accomplish plowing and harrowing in one operation.

[5] Refers to 4-wheel tractors purchased for Rp 3.2 million. At the 1981 price, (Rp 4.6 million), the mini-tractors are unprofitable at current utilization levels and contract rates.

Table 1. Socio-economic characteristics of 33 sample farms, 1981-82 wet season, Luwu, South Sulawesi, Indonesia.

I T E M	Farm category			
	Traditional farms	2W tractor farms	4W tractor farms	Tractor hirers
No. of observations	10	6	7	10
Farm size (has)	1.09	0.80	2.36	0.86
Age of household head (yrs)	45	27	36	39
Education (yrs)	5	5	8	8
Years in farming	22	6	14	17
Family size (nos.)	4	5	5	4

Table 2. Farm characteristics of 33 farmer respondents, 1981-82, wet season, Luwu, South Sulawesi, Indonesia.

Items	Farm category				
	Traditional farms	2W tractor owners	4W tractor owners	Tractor hirers	All farms
No. of respondents	10	6	7	10	33
Ave. farm size, has	1.09	0.80	2.86	0.82	1.24
Total no. of parcels	20	13	21	19	73
Ave. parcel size, has	0.547	0.36	786	454	0.559
Ave. land value/ha (Rp.000)	2239	1153	2427	2018	2142
Land tax/ha/yr (Rp.000)	45	45	45	48	46
	no. reporting (parcels)				
Soil texture					
clay	-	-	-	1	1
clay-loam	6	-	6	5	17
silt	9	8	9	6	32
silt loam	4	2	5	4	15
sandy	1	-	-	1	2
sandy loam	-	3	1	2	6
Total	20	13	21	19	73
Soil topography					
flat	20	10	18	13	61
terraced	-	3	3	6	12
Total	20	13	21	19	73
Irrigation source, by parcel					
technical irrigation system	3	-	-	-	3
simple irrigation system	17	13	21	19	70
Total	20	13	21	19	73
Tenure status by parcel					
owned	17	11	20	19	70
share-cropped	-	2	1	-	3
Total	17	13	21	19	73

Table 3. Farming practices for the 33 respondents, 1981-82 wet season, Luwu, South Sulawesi, Indonesia.

Items	Farm Category			
	Traditional farms	2W tractor farms	4W tractor farms	Tractor hirers
No. of respondents	10	6	7	10
		no. reporting		
Variety planted	IR-42	IR-42	IR-42	IR-42
		IR-48	C4	
		C4		
Planting method				
Straight-row	10	6	7	10
Main crop planted				
Rice	10	6	7	10

Table 4. Machine use and changes in farm practices summarized by parcel, comparing year before mechanization with survey year (1982), 33 respondents, Luwu, South Sulawesi, Indonesia.

Item	Farm category		
	2W tractor	4W tractor	Tractor hirers
No. of respondents	6	7	10
		no. reporting	
Used machine continuously on this parcel	13	21	19
Year machine first used for land preparation			
1982	13	-	6
1981	-	10	6
1980	-	9	6
1977	-	2	1
Total	13	21	19
Reasons for using machine:			
1. provides better quality tillage	13	18	17
2. enables farmer to plant on time	9	20	19
3. permits farmer to do other job	9	19	19
4. available for transport	4	2	-
5. less costly	4	1	-
6. eases physical burden	-	-	2
7. expand area cultivated	-	2	-
8. no human/animal labor available	-	1	-
Total	39	63	57
No. reporting change in the cropping pattern of this parcel	none	none	none
No. reporting changes in the irrigation/ water supply for parcel	13	21	19
Changes in the water supply/irrigation			
- construction of water gates	13	21	18
- construction of brush diversion dam	-	-	1
Total	13	21	19
Year changes in the irrigation system took place:			
1978	13	21	13
1979	-	-	6
Total	13	21	19

Table 5. Factors considered in decisions to purchase tractors, Luwu, South Sulawesi, Indonesia, 1982.

Item	Farm category	
	2W tractor	4W tractor
No. of respondents	6	7
Machine horsepower	6	12
Fuel type	diesel	diesel
Implement attached	plow & harrow	rotovator
Persons involved in decision to buy machine:	no. reporting	
- family member	-	4
- extension worker	3	1
- farmer's organization	-	2
- no answer	3	-
Total	6	7
Advantages of owning machine considered in purchase decision:		
1. enables farmer to plant on time	4	7
2. provides better quality tillage	6	5
3. available for transport	6	1
4. saves time, farmer may do other jobs	-	5
5. less costly	2	-
6. allows expansion of cultivated area	-	2
7. eases physical burden	-	1
total no. reporting	18	21

Table 6. Financing characteristics of 33 respondents, 1981-82, wet season, Luwu, South Sulawesi, Indonesia.

I T E M	Farm Category			
	Traditional	2W tractor	4W tractor	Tractor hirer
No. of respondents	10	6	7	10
No. of household with financial liabilities	8	6	7	10
Duration of liabilities (months):		no. reporting		
1-6	8	5	7	10
7-36	-	1	-	-
37-96	-	-	5	-
Security or collateral:				
building	1	2	2	2
land title	7	3	5	8
personal note	-	1	-	-
Purpose of the loan:				
seasonal farm expenses	8	6	7	10
Sources of loan:				
government through banks	8	4	7	9
friends/relatives	-	2	-	-
others		-	-	1
Interest rate/year:				
12%/yr	8	6	7	10
Ave. amount of liability, (Rp.00):	234.5	202	5895.6	223.9

Table 7. Ownership of power source and implements by type of farm, 1981-82 wet season, Luwu, South Sulawesi, Indonesia.

I T E M	FARM CATEGORY			
	Traditional	2W tractor	4W tractor	Tractor hirers
No. of respondents	10	6	7	10
		No. of unit reported		
Machine owned:				
2-wheel tractor	-	6	-	-
4-wheel tractor	-	-	7	-
Implements owned:				
Plow	12	2	3	6
Rotovator	-	-	7	-
Harrow	27	15	18	19
Draft animals owned:				
oxen/cattle	27	10	8	25

Table 7a. Farm implements owned by the respondents by farm category Luwu, South Sulawesi, Indonesia, wet season 1981-82.

I T E M	FARM CATEGORY			
	Traditional	2-WT	4-WT	Tractor hirers
No. reporting	10	6	7	10
		Rp (00) per farmer		
Type of farm implements, total units				
rotovator	-	-	429 (1)	-
sprayer	255 (.6)	493 1	380 (.9)	382 (.8)
ox plow	185 (1.2)	62 (.3)	74 (.4)	102 (.6)
sacks	77 9.5	96 14.2	165 27.1	.69 (9.1)
hoe	80 (1.9)	63 1.3	82 (1.9)	62 (1.5)
harrow	57 (2.7)	63 2.5	61 (2.6)	44 (1.8)
machet	44 (1.3)	45 (1.3)	39 (1.1)	40 (1.2)
axe	18 (.6)	20 0.7	31 (1)	28 (.9)
mechanical weeder	17 (1.8)	- -	19 (1.9)	12 (1.2)
saw	11 (.3)	15 (0.5)	27 (.7)	22 (.5)
winnower	9 (.9)	10 (1.0)	14 (1.3)	11 (1.1)
flail	7 (.7)	5 (0.5)	7 (.7)	9 (.9)
plastic container	6 (1.2)	6 (1)	6 (1)	4 (1.6)
sickle/scythe	0.10 (.1)	7 (0.7)	- -	0.2 (.2)
basket	18 (1.7)	20 1.8	30 (3)	24 (2.5)

Figures in parenthesis are average number of units owned by farmers.

Table 8. Material inputs by farm category by season, Luwu, South Sulawesi, Indonesia, 1981-82.

I T E M	FARM CATEGORY									
	Traditional		2-WT owner		4-WT owner		Tractor hirer		All farms	
	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS
No. of respondents	10		6		7		10		33	
Average farm size, ha	1.09	1.07	0.80	1.0	2.36	2.36	0.86	0.69	1.24	1.21
					Rp/ha					
Seeds (kgs)	3908 (28)	4163 (18)	5535 (40)	5108 (20)	2606 (20)	3527 (14)	4031 (43)	5422 (22)	3598 (30)	4259 (18)
Fertilizer[a/] (kgs)	7665 (108)	5370 (77)	3874 (54)	5454 (78)	6129 (105)	1154 (16)	8479 (122)	5584 (80)	6774 (103)	3683 (53)
Pesticides/Insecticides[b/]	6685	1126	4872	1472	3066	891	4108	1904	4370	1214

a/ Some 4WT owners and tractor hirers used compost fertilizers on their farms but there was no money value indicated.

b/ Dry season operations recorded were only up to transplanting and partial fertilizer and pesticide applications.

Rupiah 625 = US$1

Figures in parentheses are amount in kilograms per hectare.

Table 9. Production and disposal of products by 33 respondents, 1981-82 wet season, Luwu, South Sulawesi, Indonesia.

I T E M	FARM CATEGORY				
	Traditional farms	2W Tractor owners	Tractor hirers	4W Tractor owners	All farms
No. of observations	10	6	10	7	33
Average farm size, has	1.09	0.80	0.86	2.36	1.24
			t/ha		
Total production	2.35	2.25	2.88	2.48	2.50
Paid to harvesters/threshers	0.34	0.32	0.41	0.36	0.35
Paid to other debts	0.17	0.25	0.25	0.24	0.23
Retained for home consumption, seeds, etc.	1.31	1.20	1.02	1.24	1.21
Amount sold	0.43	0.44	1.16	0.61	0.66
Retained for other purposes	0.10	0.04	0.04	0.03	0.05
Average price/kg (Rp)	100	100	100	100	100

Table 10. Labor utilization by operation, power source and farm category, wet and dry seasons, 1981-82, Luwu South Sulawesi, Indonesia.[a]

ITEM	FARM CATEGORY							
	Traditional		2-WT owners		4-WT owners		Tractor hirers	
	WS	DS	WS	DS	WS	DS	WS	DS
No. reporting	10	10	6	6	7	7	10	10
Average area farmed, ha	1.09	1.07	0.80	1.0	2.36	2.36	0.86	0.69
No. using draft animals	10	10	3	4	7	7	9	10
					manhours/hectare			
Seed/seedbed preparation								
Man	55 (72)	10 (0)	37 (0)	9 (0)	14 (79)	5 (0)	63 (60)	25 (0)
Animal	13	11	5	3	1	4	26	17
Tractor	-	-	11	3	1	0.4	-	0.4
Land preparation								
Man	74 (12)	79 (0)	55 (30)	40 (17)	20 (16)	24 (44)	51 (63)	38 (79)
Animal	148	156	9	16	9	22	49	32
Tractor	-	-	37	31	15	13	12	21
Plowing								
Man	39 (11)	44 (0)	25 (31)	13 (0)	8 (0)	10 (0)	20 (59)	16 (97)
Animal	81	88	-	-	-	-	15	-
Tractor	-	-	17	13	8	10	6	16
Harrowing/levelling/puddling								
Man	36 (14)	35 (0)	30 (30)	27 (24)	12 (33)	14 (75)	31 (68)	22 (66)
Animal	67	68	9	16	9	22	34	32
Tractor	-	-	20	19	7	3	6	5
Transplanting/Pre-transplanting operations								
Man	121 (98)	150 (95)	130 (88)	117 (96)	46 (93)	44 (96)	126 (93)	209 (95)
Animal	-	2	-	-	1	3	5	2
Irrigation/drainage/cleaning dikes[a]								
Man	31 (12)	15 (17)	47 (28)	22 (52)	34 (62)	10 (59)	37 (22)	18 (31)
Fertilizer/Pesticides application[a]								
Man	43 (0)	5(0)	32 (0)	33 (6)	5 (0)	33 (6)	52 (26)	7 (0)
Harvesting/Threshing/Cleaning								
Man	75 (100)	-	87 (100)	-	65 (100)	-	109 (97)	-
Transporting/Bagging/Packing/Drying								
Man	7 (47)	-	14 (50)	-	6 (24)	-	11 (24)	-
Animal	-	-	-	-	-	-	-	-
Tractor	-	-	-	-	2	-	-	-
TOTAL HRS/HA[a]								
Man	496 (64)	259 (56)	456 (60)	193 (68)	259 (57)	86 (74)	509 (73)	291 (80)
Animal	161	169	14	19	11	29	80	51
Tractor	-	-	48	34	18	13.4	12	21.4

[a] Dry season record was not completed. Fertilizer and pesticide application and irrigation and cleaning dikes were only partially recorded.

[b] Total labor input for dry season crop included only up to partial fertilizer and chemical applications.

Table 11. Power inputs (hrs/ha) from seedbed preparation to transplanting/pre-transplanting operations by farm category, 33 respondents, wet and dry seasons, 1981-82, Luwu, South Sulawesi, Indonesia.

ITEM	FARM CATEGORY							
	Traditional farms		2WT owning farms		4WT owning farms		Tractor hiring farms	
	DS	WS	DS	WS	DS	WS	WS	DS
No. of observation	10	10	6	5	7	7	10	10
Ave. farm size, ha	1.09	1.07	0.80	1.0	2.36	2.36	0.86	0.69
No. using draft animals	10	10	3	4	7	7	9	10
	manhours/hectare							
Seed/seedbed preparation								
Man	55 (72)	10 (0)	37 (0)	9 (0)	14 (79)	5 (0)	63 (60)	19 (0)
Animal	13	11	5	3	1	4	26	17
Tractor	-	-	11	3	1	0.4	-	0.4
Land preparation a/								
Man	74 (12)	79 (0)	55 (30)	40 (17)	20 (16)	24 (44)	51 (63)	38 (79)
Animal	148	156	9	16	9	22	49	32
Tractor	-	-	37	31	15	13	12	21
Transplanting								
Man	121 (98)	150 (95)	130 (88)	117 (96)	46 (93)	44 (96)	126 (93)	209 (95)
Animal	-	2	-	-	1	3	5	2
Tractor	-	-	-	-	-	-	-	-
TOTAL								
Man	250	239	222	166	80	73	240	266
Animal	161	169	14	19	11	29	80	51
Tractors	-	-	48	34	16	16.4	12	21.4

a/ Land preparation includes plowing, harrowing, levelling, puddling.
Figures in parentheses are percent hired labor.

Table 12. Repair and maintenance costs for four-wheel and two-wheel tractors and total area serviced from year of purchase to present, Luwu, South Sulawesi, Indonesia.

CROP YEAR	Season no.	4-wheel tractor 101	102	119	120	121	122	123
					Rupiah			
1977 - 78	1	-	-					
1978	2	18,500	7,000					
1978 - 79	3	37,500	22,500					
1979	4	58,000	12,300					
1979 - 80	5	29,750	a/					
1980	6	34,000	34,000					
1980 - 81	7	43,400	a/		11,750	21,500		
1981	8	43,500	14,900	13,000	42,250	50,000	15,000	12,800
1981 - 82	9	18,000	14,500	42,000	72,400	71,000	66,000	74,000
Average total cost, Rp/season		35,331	17,533	27,500	42,133	47,500	40,500	43,400
Average area served, ha/season		8.65	3.05	25.45	18.14	9.75	16.62	22.87
Total cost Rp/ha		4,084	5,749	1,081	2,322	4,872	2,436	1,898

CROP YEAR		2-wheel tractor 116	117	118	134	135	136	All
					Rupiah			
1981-82	1	5,000	6,000	5,000	6,750	6,500	7,000	6,042
1982	2	7,500	9,000	7,500	10,125	9,750	10,500	9,062
Average total cost, Rp/season		6,250	7,500	6,250	8,438	8,125	8,750	7,552
Total area served, ha /season		15.67	31.96	25.06	20.82	25.72	20.67	
Average total cost Rp/ha		349.65	294.64	415.56	394.09	302.38	433.70	357.28

a/ Tractor was not used for cultivation.

Table 13. Two-wheel tractor cost analysis for wet and dry season 1981-82 Luwu, South Sulawesi, Indonesia.

ITEM	2-Wheel Tractor Wet season	2-Wheel Tractor Dry season	4-Wheel Tractor [a] Wet season I	4-Wheel Tractor [a] Wet season II
Initial cost, Rp 000	1625	1625	3200	4600
Fixed Cost Per Season, Rp. 000				
Depreciation, 10% salvage value [b]	183	183	240	345
Interest on average capital investment 12% per year	54	54	106	152
Total fixed cost/season	237	237	346	497
Variable Cost/ha, Rp				
Diesel fuel [c]	1954	(2008)	4200	4200
Oil [c]	281	( )	570	570
Repair and Maintenance	259	478	3134	3134
Operator's fee [d]	2529	2683	6200	6200
Total variabce cost/ha operation	5023	5169	14104	14104
Total Utilization/season (ha) [e]	23.32	18.96	16.35	16.35
Total variable cost/season	117,136	98,004	230,600	230,600
Total cost, Rp	354,136	335,004	576,600	727,600
Total benefits, Rp [f]	431,950	370,758	654,000	654,000
NET INCOME, Rp	77,814	35,754	77,400	-73,600
Payback period, seasons [g]	6.2	7.4	10.1	17.0
Break-even point, ha/season	15.8	16.0	13.4	19.2
Benefit-cost ratio	1.22	1.11	1.13	0.90

[a] Four-wheel tractors were calculated at 2 alternative initial investment levels reflecting the difference in costs to those who purchased machines in 1977 (I) and 1981 (II). No dry season data was available.

[b] Depreciation was computed using straight line method, salvage value of machine at 10%, 2-wheel tractors having a 4-yr life (or 8 seasons) and 4-wheel tractor, 6-year life (or 12 seasons).

[c] Diesel fuel was priced at Rp 125/l and oil at Rp 1000/l.

[d] Operator's fee was costed at Rp 3500/ha for plowing and Rp 2000/ha for harrowing 2WT while for 4WT- rotavation the charge was 15.5% of custom rate/ha (15.5% of Rp 40,000).

[e] Total utilization/season in has including own farm and custom work.

2WT:	wet season	dry season
Plowing =	8.22 ha	8.64 ha
Harrow =	~~10.32~~ ha 15.10	10.32 ha
	23.32 ha	18.96

4WT: Wet season

Rotavating: 16,35 ha

Dry season - not available

[f] Contract rates by operation:

4WT: rotovation - Rp 40,000/ha

2WT: plowing - Rp 25,000/ha)
harrowing - Rp 15,000) or an average of Rp 20,000/operation.
(2 passes)) This was used in computing the B.E.P. of 2WT units.

[g] Payback period was computed as follows:

$$PBP = \frac{\text{Initial cost}}{\text{Total Cross Benefits less variable cost + Interest on Ave. Capital Investment}}$$

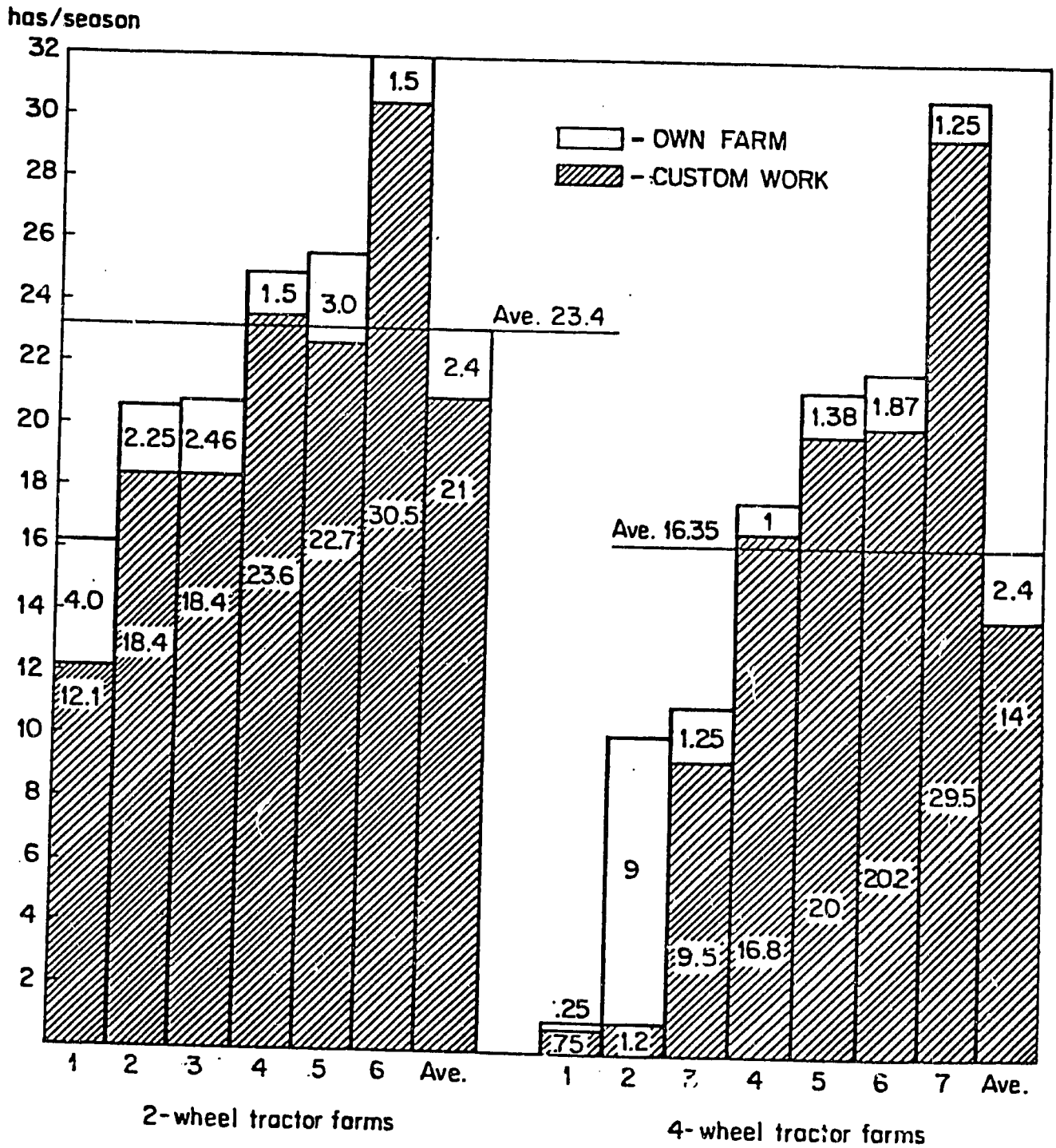

Fig. 1. Tractor utilization by tractor type for 1981-1982, wet season, Luwu, South Sulawesi, Indonesia.

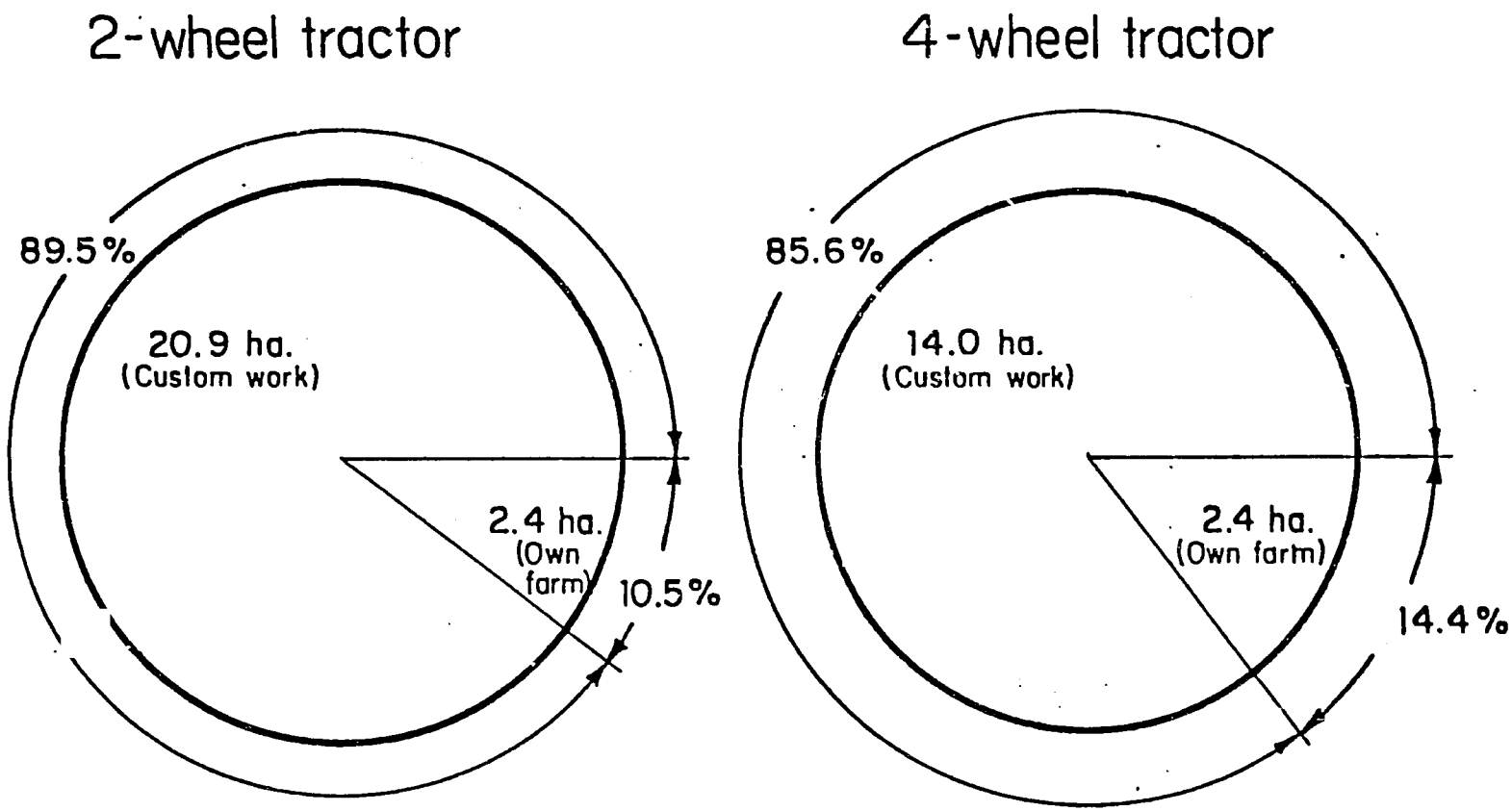

Fig.. 2. Comparative utilization by tractor type and location of activity, 1981-1982, wet season, Luwu, South Sulawesi, Indonesia.

NOTE:
The 6 2-wheel tractors each cultivated an average total area of 23.39 hectares including plowing and 2-harrowings while the 7 4-wheel tractors serviced 16.4 hectares having rotavation only which is equivalent to both plowing and harrowing with the 2-wheel tractor.

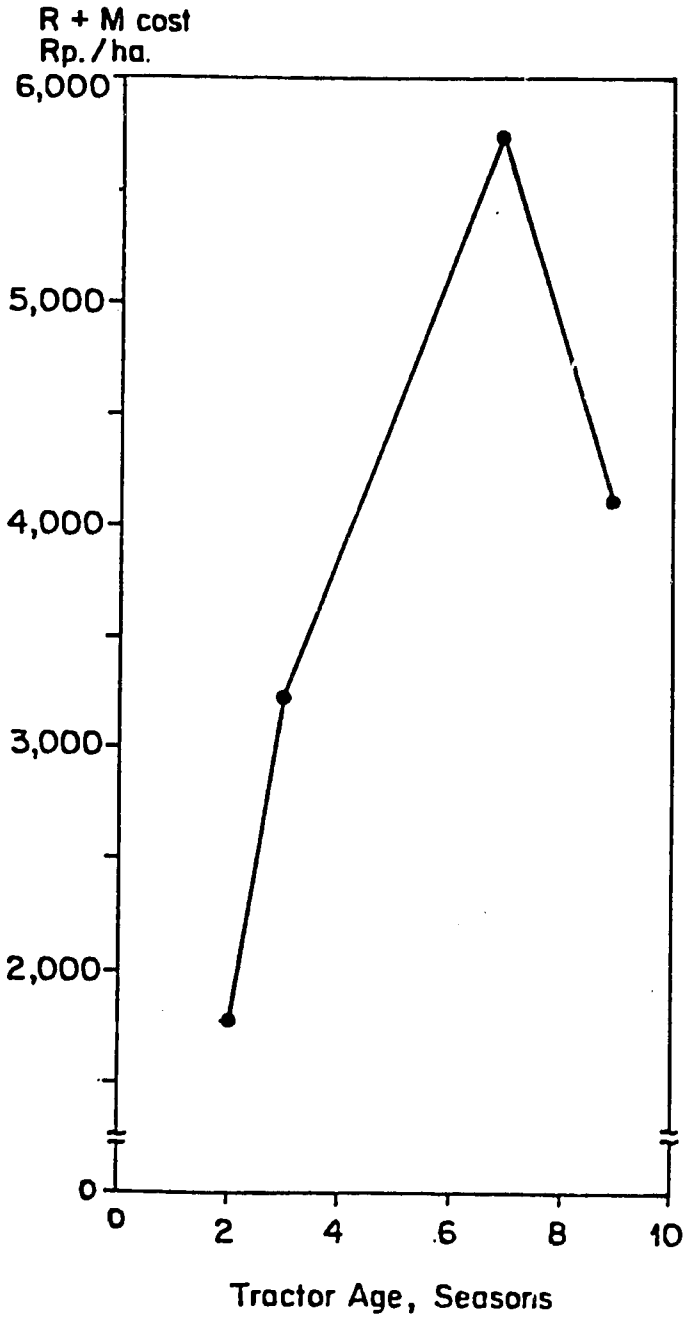

Fig. 3. Repair and maintenance cost per hectare by tractor age, four-wheel tractor, Luwu, South Sulawesi, Indonesia.

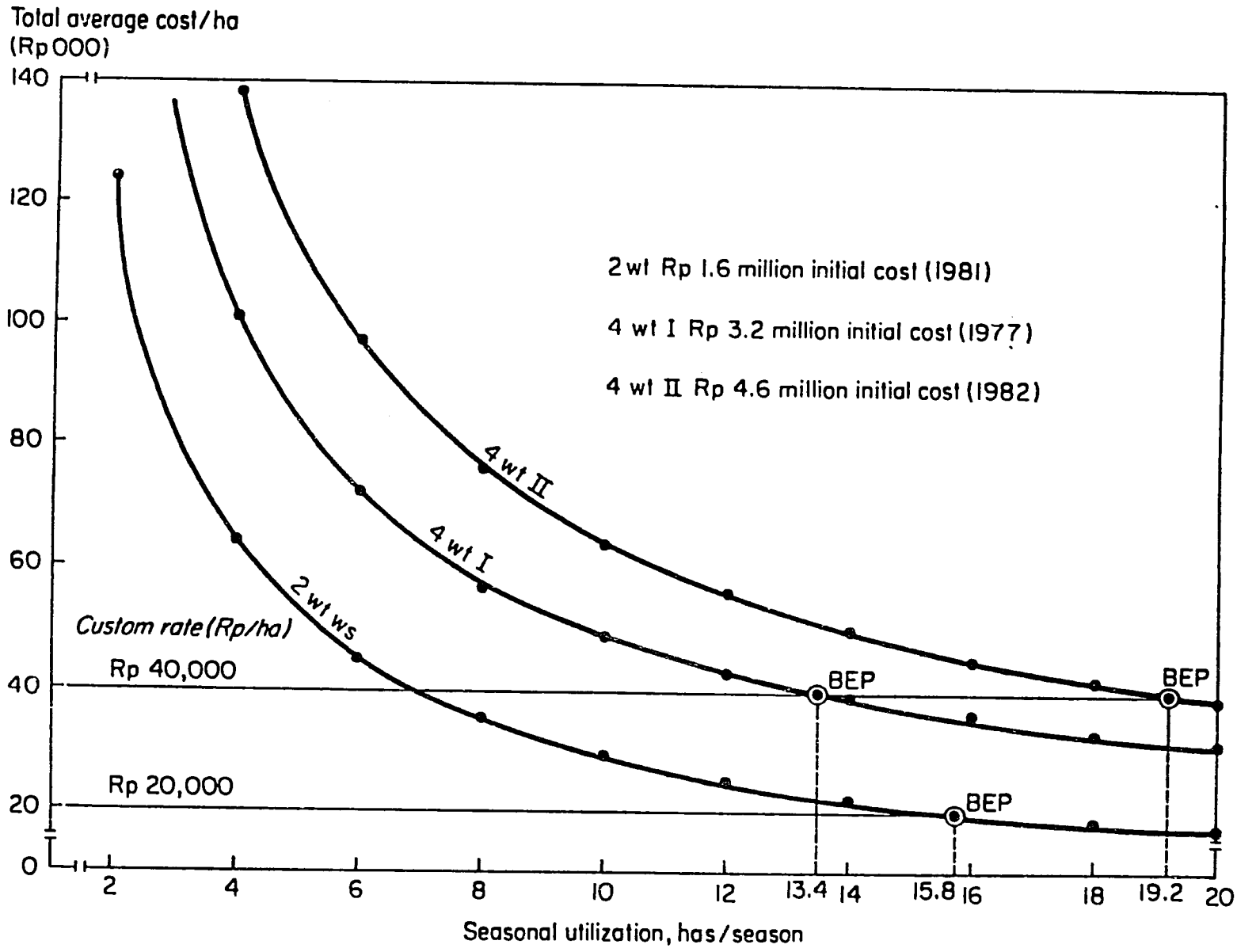

Fig. 4. Breakeven analysis for 4-wheel tractor at two alternative investment costs and 2-wheel tractor, Luwu, South Sulawesi, Indonesia.