THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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AN ECONOMIC COMPARISON OF MANUAL, ANIMAL, AND TRACTOR LAND PREPARATION IN WEST JAVA, INDONESIA

by

Ketut Nehen
Monash University
Australia

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INTRODUCTION

Agricultural mechanization, particularly rice milling and hand-tractor utilization[1], has significantly incresed in Indonesia recently. For example, the total number of hand tractors in West Java has increased from 431 in 1974 (Saefudin, 1981) to more than 1500 in 1979 (Agricultural Extension Service, West Java, 1980) or by a factor of 3.5. However, the use of tractors in land preparation[2] in sawah (lowland ricefields) rice cultivation in densely populated parts of Indonesia has been a major issue of debate in recent years (IRRI Mechanization Consequences Research Team, 1981; Rijk, 1979; Simatupang, 1980; Sinaga, 1978). The interest in mechanizing land preparation is based on the hypothesis that land preparation with the aid of a tractor (TLP, hereafter) increases production and/or reduces the cost of land preparation. Binswanger (1977) refers to the former as the net contribution effect and to the latter as the substitution effect. On the other hand, TLP is criticized because of its expected negative effects on employment and income distribution (Satya Wacana, 1979; Sinaga, 1978).

The Government of Indonesia realized that in a land-scarce area like Java increased yields and increased cropping intensity are the most obvious ways of increasing agricultural (rice) production. An important government move in this respect is the improved scheduling of irrigation water availability so that there will be enough water for two or three crops a year in some areas. As a result, planting must be synchronized over a relatively wide area, and each cropping

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[1] In this paper the term tractor will refer to the hand-tractor or power-tiller which has two rather than four wheels.

[2] In this paper land preparation will refer to ploughing and harrowing only.

phase has to be performed over a relatively short period. Land preparation between crops must be done rapidly and simultaneously with the harvesting the previous crop. Since wages for harvesting are often higher than those for land preparation, it is argued that a shortage of manual and animal power for land preparation arises (Sub-Directorate of Agricultural Mechanization, Dept. of Agriculture, 1976; Agricultural Extension Service, West Java, 1980). TLP has been introduced in an attempt to ease the apparent shortage of human and animal power that are believed to constrain increased cropping intensity. TLP has been adopted not only by large farmers who can afford to buy tractors, but also by smaller farmers who hire tractors from the former so that tractor hiring among farmers has become a common practice in some regions in rural Java.

Some writers (Sawit and Saefudin, 1979; Sinaga, 1978; Sinaga, et. al., 1980, Rochim and Bernsten, 1980) observe that rural labor is abundant in Java and are concerned about the potential negative impact of the widespread use of TLP on rural employment and income distribution. It is argued that the use of tractors may transfer more than one million rupiah (about $US1,600)[3] per year away from laborers to tractor owners, tractor renters, tractor dealers, gasoline and oil suppliers and so on. In other words, TLP may result in a loss for landless laborers and small farmers and a gain to the other richer members of society.

The practice of hiring tractors widens the range of alternative techniques available for land preparation. The problem becomes the determination of the technique best suited to the particular conditions involved in rice cultivation in West Java. This study, therefore, seeks to determine the most desirable LP technique from the private point of view i.e., that of farmers with land holding of different sizes who either own or hire labor and equipment for LP. It also attempts to determine the most desirable LP technique from the point of view of the society as a whole, taking into account the ownership of the equipment and the different sizes of individual farms.

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[3]Based on a $US1 = RP 625 exchange rate.

METHODOLOGY

Cost-benefit analysis will be used to evaluate alternative land preparation techniques. All costs and benefits associated with each technique are enumerated, valued and then assessed using an appropriate interest rate and either the net present value or internal rate of return approach. Specifically, the effects of each technique on the volume and value of the rice output, and on employment and income distribution are considered. The volume effects are based solely on yield. The contributions of cropping intensity and pattern and the expansion of cultivated area to volume are not considered.

The optimum technique from the point of view of hirer farmers is that which maximizes the annual per hectare net returns from the cultivation of their own sawah. The returns are equal to the market value of the rice yield less input costs including seed, land preparation and harvesting costs. Rice yield production functions are estimated for each technique using linear and log-linear functional forms with rice yield as the dependent variable and farm inputs, pre-harvest labor and some dummy variables (location, soil texture, and LP technique dummies) as the independent variables. The rice yields for the hirer and the owner farmers are assumed equal, and are estimated by substituting the average levels of farm inputs and the frm size into the estimated rice yield functions. Production functions are estimated separately for the wet and the dry seasons.

From the point of view of the equipment owners the problem is whether to buy equipment for ALP (land preparation with the aid of an animal) or TLP or simply carry out MLP (land preparation using manual labor only) on their own sawah using family and hired labor. The equipment is assumed to be first used on the owner's sawah with any extra capacity hired out for custom work. The benefits of each LP technique except MLP consist of net returns from cultivating the owner's sawah and earnings from custom work. The benefits and costs of owner's and customer's sawah LP are estimated for the whole life of the power source, assumed to be 7 years for both animals and tractors. Using the market rate of interest, the NPV for each technique over 7 years is computed and used to rank the techniques.

From the point of view of the entire economy the problem is determining the most desirable technique for preparing a particular area of fully irrigated sawah in the sampled kabupaten. Three separate analyses are conducted. These are analysis at market prices, efficiency analysis, and an analysis addressing the income distribution objective.

Social analysis at market prices is similar to the private analysis from the point of view of the owner farmers, except that earnings from custom work are not counted. The optimum technique is that which yields the highest present value over 7 years of net benefits from cultivating the entire fully irrigated sawah under study discounted at the market rate of interest. All benefits and costs are valued at market prices.

In the efficiency analysis all components of benefits and costs are valued at efficiency prices, i.e. the prices that reflect the value of inputs and outputs to the society as a whole given the existing distortions in the input and output markets. These prices are not the equilibrium prices which would prevail in a distortion-free economy. In deriving efficiency prices components of benefits and costs of each technique are classified into traded goods, non-traded goods, and labor. Border prices (cif prices for importable goods or import substitute and fob prices for exportable goods) are used as approximations for the efficiency prices of traded goods.

For the valuation of non-traded goods, three alternative approaches are considered: one based on the marginal social benefits of inputs or of consumption goods on the marginal social costs (applying a decomposition procedure) and the use of a standard conversion factor (SCF). In this study the SCF is estimated using the ratio of the effeciency prices to market prices of traded goods weighted according to quantity produced or used in the project.

In the case of labor valuation, the differences between the labor market for unskilled general agricultural labor such as that for hoeing, animal care, transplanting, weeding, and harvesting, and the market for skilled labor such as that for ploughing and driving and repairing tractors are taken into account. The discussion concentrates on the labor market institution, wage rate fluctuations and job availability information. For purposes of this study the market wage rate is considered a good approximation of the efficiency wage at the margin.

Continuation of preceding LP labor is valued at its opportunity cost or at the average of daily wages of pre-harvest activities except LP work and daily income from off-farm and non-farm.

The interest rate used is the weighted average of the social time preference rate and the social opportunity cost of capital. The NPV at efficiency prices is then estimated for each technique and used to rank them.

To estimate the distributional effect of each technique the incremental financial benefits for each affected group of individuals is estimated and then adjusted using the distributional weights assigned to the income levels of the beneficiaries. The income distribution associated with each technique becomes relevant particularly when there is redistributive effects accompanying a switch in technique. For example, individuals involved in the replaced technique may incur negative net financial benefits, while other grups may gain. In estimating incremental financial gains MLP is used as the base technique. The financial net benefits that accrue to different groups because of a switch from MLP are classified into direct and indirect benefits. The former includes the gains and losses accruing to individuals associated with both the replaced and adopted technique while the latter includes those that might be received by individuals not directly related to either LP technique. Examples of indirect benefits are those received by a butcher who buys old buffaloes, by producers or traders of tractors and parts, gasoline, oil and traditional farm implements. Indirect benefits are assumed to be zero, because beneficiaries may gain the same benefits in alternative business activities.

The groups directly affected by the switch from MLP to ALP are farmers, ploughmen, animal care takers, and hoers. If the switch is from MLP to TLP, the groups directly affected are farmers, tractor drivers, mechanics and hoers. In both cases, hoers are losers, while all other groups are the gainers.

Farmers have two sources of net financial gains: farming and custom work. In this study it is assumed that LP equipment is owned by farmers, and not by non-farmers. The net financial gains for farmers who switch from MLP may be in the form of increased yield and decreased cost of LP. The increase in yields is the difference in rice yields associated with alternative techniques. The decrease in LP cost is the difference between the hiring cost of alternative techniques in question. Both forms of gains are estimated for the whole fully irrigated area under consideration.

In the case of net financial gains of owners of LP equipment, four alternative ownership patterns are studied. These are the ownership by all farmers of their own LP equipment, ownership by small farmers only, ownership by medium farmers only, and ownership by large farmers only. The net annual financial benefit is the difference between the total earnings from renting out the equipment and the total outlay during that year. These net financial benefits are estimated for the whole productive life of the power source assumed to be 7 years for both ALP and TLP.

The net financial benefit of other groups is the difference between the total earnings from LP work and the earnings they would have earned in an alternative occupation. For ploughmen, animal care takers, tractor drivers and hoers, the alternative occupation is assumed available in farm and non-farm sectors. Their alternative earnings per day are assumed to be equal to the average of daily wages for pre-harvest activities and daily off-farm and non-farm income. The loss per day for hoers is the daily wage for hoeing less the average income hoers can receive in alternative job opportunities. Mechanics are assumed to have about the same level of income in alternative employment, so that they do not gain from farmers switching to TLP.

Having estimated the net financial benefits accruing to different groups of individuals, these benefits are then adjusted using the distributional weights assigned to the beneficiaries. The distributional weights are based on an implicit value judgement of the shape and magnitude of the marginal utility of income function. The elasticity of the marginal utility of income is discussed, but because of the lack of data, it cannot be estimated in this study so that alternative values are assumed for it as follows; 0, -0.5, -1.0 and -1.5. The annual income levels of relevant groups are estimated and using the weight assigned to hoers as base (unity), we estimate the weights of other groups relative to that of hoers. The net benefits accruing to the society as a whole for each LP technique is then the sum of the adjusted net financial benefits for each group. The net present value of this sum is computed and used to rank the techniques.

SOURCES OF DATA

The study analyses a portion of the 1979/80 wet and the 1980 dry season data for West Java collected for the IRRI study. It includes only those farmers who use a single source of power for ploughing and harrowing. After eliminating all farmers using combined sources of power and those who gave incomplete information, the study analyses the cases of 197 farmers and 60 landless laborers. The distribution of samples by village and type of power used for LP is shown in Table 1.

In the dry season farmers usually practice MLP with minimum tillage (walik jerami), which involves cutting the straw, spreading it then treading upon it evenly in the field. During the dry season all the 50 farmers using an animal power actually use NLP but they are treated as ALP cases in order to complete ALP data for the dry season.

IRRI's West Java study was conducted in Subang and Indramayu. Four sample villages with a high proportion of farmers using TLP were selected from each region. Before selecting the sample farmers, a block census was conducted in all sample villages, covering over 1600 households, of which 977 were farm households. Classifying farm according to size shows that 40% of farms are small, 23% are medium, and 29% are large. Small, medium and large farmers own about 15, 18, and 67 percent of the total sawah respectively. The average farm size in each group are 0.5 ha, 1.5 ha and 4.5 ha respectively.

Sample farmers were asked about the levels of inputs used, their output, and other basic information on rice farm operation. The average rice yields per ha varied very widely both between farmers in each village and between villages and kabupaten (Table 2). Farmers using tractors recorded a higher average yield farmers using than manual and animal power in both seasons, although during the wet season yields of the former were only slighly higher (Table 3). Data on farm inputs suggest only small differences in the average levels of nitrogen use and of expenditures for insecticides and pesticides. Tractorized farming, however, used a higher average level of trisuperphosphate and less pre-harvest labor than both animal and manual farming methods.

RESULTS AND DISCUSSION

Overall, the production function estimates only provide weak evidence for the hypothesis that alternative techniques are associated with different yields. This study therefore examines the case where yields are not different as well as those where they are different. In the latter case, linear production function estimates which provide a statistically better fit are chosen rather than log linear estimates and those with the highest R^2 are used (Table 4).

In the case where rice yields do not vary across techniques (hereafter referred to as case i), the rice yields for each technique are assumed equal to the average estimated rice yields for each farm size and each LP group. These are obtained by plugging the average levels of farm inputs and average farm sizes for each farm size group into the estimated functions.

In the case where yields vary across techniques (the net contribution effect), two self cases are studied. The first involves yields which also vary across different farm sizes (hereafter referred to case ii). Rice yields for different farm sizes and different techniques are estimated by plugging in the average level of farm inputs together with the average farm size into the estimated production functions. The second involves yields which vary only across different techniques but do not vary with farm size (hereafter, referred to as case iii). Estimated yields for this case are obtained from the rice yield function by substituting the average levels of farm inputs together with the average farm size for all sampled farmers. The rice yield estimates for the different cases are presented in Table 5.

Table 6 shows the net benefit associated with each technique for the different cases. The estimates are based on the market value of the rice yields presented in Table 5 and the costs of farm inputs, including the costs for seeds and harvesting. They exclude the costs of LP, which are treated separately.

THE CASE OF HIRER FARMERS

The optimum technique for hirer farmers depends on whether yields vary across techniques or not. In case (i) where yields are equal, the relevant consideration for hirer farmers is the cost of LP per ha. On a yearly basis ALP seems to be the cheapest technique when the value of meals is excluded (Table 7), followed by MLP and then TLP. However, if the value of meals is included, ALP is still the cheapest, but TLP become a cheaper technique than MLP.

In case (ii) TLP provides the highest net returns per ha for small and medium farms, while ALP provides higher returns per ha for large farms (Table 8). This is because the farm size effects are high and negatively correlated to yield in the case of TLP but not so with ALP and MLP (Table 5). The yield per ha drops substantially as the farm size increases with TLP, while there is only a slight drop in yields with ALP as farm size increases. In case (iii) ALP is optimum regardless of whether the value of meals is taken into account or not. However, it gives only a slightly higher return per ha than TLP.

THE CASE OF OWNER TRACTORS

In this study rice yields are assumed not to vary according to whether the farmers are hirers or owners of the technique. As with hirer farmers, owner farmers are guided by the net returns associated with particular technique. In other words, the owner farmers can be considered as hirers of their own LP equipment. In addition to the benefits they obtain from hiring their own LP equipment, they also earn income from doing custom work when their LP equipment is not fully utilized on their own farms.

The income from from custom work is only relevant for ALP and TLP. In the case of ALP, small and medium farmers are assumed to have 1 pair of buffalo and traditional farm implements. They are assumed to earn income from custom work totalling Rp 5,000 and Rp 17,500 per year respectively. Large farmers are assumed to have 3 pairs of buffalo and traditional farm implements, and to have no interest in doing ALP work on other people's farms for income. Their income from custom work is therefore zero.

In the case of TLP, the owner is assumed to have only one 7-8 hp gasoline tractor requiring an initial investment cost of Rp 1,750,000. It can be used for 54 days per season or for a total of 18 ha/season (case a). Since the IRRI study indicates that tractor owners can do LP for only about 13 ha/season (owned and on other people's sawah), a capacity of 13 ha/season (case b) is also examined. Each power unit is assumed to be used first for LP on the owner's sawah, and then hired out. Based on a 10% discount rate the results of the analysis indicate that in case (i) MLP is desirable for small farmers, TLP for large farmers, while medium farmers will be indifferent between MLP and TLP. However, as TLP and ALP have higher yields than MLP (cases ii and iii), these two techniques are preferred to MLP particularly by medium and large farmers. Small farmers consider ALP as the least preferable technique (Table 9).

In analyzing the impact of each LP technique on the whole society it is assumed that each technique is used to do LP for the whole fully irrigated area in the two sampled kabupaten (=133,000 ha). Given the amount of time required for each LP technique and the total working days per season or per year the total power unit and equipment requirement for each technique can be determined. For example, a pair of buffalo works for 30 days per year and requires 16 days to prepare one ha of sawah (Table 7). The total number of buffaloes required for 133,000 ha therefore is about 71,000 pairs. This is about 3 times the total number of buffaloes in both kabupaten in 1979. When all fully irrigated sawah in the two kabupaten are prepared using a single LP technique, the prices of the components of benefits and costs of each technique may differ from those used in the preceding analysis. Since no information is available for estimating such prices, the 2 sets of prices are assumed equal in this study.

Analysis at Market Prices.

This analysis uses the same benefit and cost data as in the preceding analysis. The results of the analysis indicate that in case (i) TLP is slightly preferable to MLP only if each tractor is used 18 ha/season, but yields a lower NPV vs. MLP when used for only 13 ha/season. ALP also yields a lower NPV than MLP in case (i). In cases (ii) and (ii), however, both ALP and TLP have higher NPV, even when each tractor is used only for 13 ha/season (Table 10).

Efficiency Analysis

In this analysis rice, nitrogen, trisuperphosphate, insecticides and pesticides, tractors and spare parts for tractors are classified as traded goods and are valued at international prices. The value of the rice output of 133,000 ha is about 33 percent higher at international prices than its value at domestic prices. In cases (ii) and (iii), where TLP and ALP have higher yields than MLP, the valuation of rice at efficiency prices tends to favour TLP and ALP. On the other hand the value of tractors at international prices is only about 60 percent of that at domestic market prices which tends to make TLP more attractive. Valuation of other traded goods at efficiency prices yield only minor effects on the desirability of each technique, as they are either used in all techniques or used only sparingly.

Bufaaloes and traditional farm implements are classified as non-traded goods. Their values at efficiency prices are their domestic prices multiplied by the SCF (=1.22). They therefore have a higher value at efficiency prices than at market prices. The net effects of this valuation is to make ALP more profitable, because the increase in the selling price of buffaloes and residual values of traditional farm implements are higher than the increase in the initial investment for them.

Valuation of labor at efficiency wages is about 35 percent lower than the market wage. As a result WLP and ALP become more attractive. The efficiency analysis shows that if yields do not differ for different techniques, then MLP is optimum. If TLP and ALP produce higher yields then TLP is the most desirable technique (Table 11).

Social Analysis Using Distributional Weights

The income levels of the affected groups are estimated from farm income, and off-farm and non-farm incomes obtained from the IRRI study. Using assumed values for the elasticity of marginal utility of income, the distributional weights for each group of individuals are estimated. With a value of -0.5 for the elasticity of marginal utility of income, for example, the highest distributional weight is 1.20 for landless labourers and the lowest is 0.37 for large farmers whose annual income is about 10 times that of the landless laborers.

In this paper the case where all farmers switch technique is examined. The annual net financial benefits for affected groups are estimated and weighted according to the appropriate distributional weights. The estimate is done for 7 years using a 6 and 8% social discount rate. A negative (positive) NPV implies that the technique under consideration is less (more) attractive compared to MLP. In other words, the NPV of the base technique (MLP) is zero.

The results of the analysis indicate that the optimum technique depends on the yield associated with each LP technique. In the case where there is no yield difference across techniques, MLP is the most desirable technique, but if TLP and ALP have higher yields than MLP (cases ii and iii). TLP or ALP become optimum depending on the distributional weights used. As the weights become more biased in favor of the poor ALP becomes the optim technique, while TLP is optimum if policy makers are not biased in favor of the poor.

In case (i) the NPV of social gains of each technique (except MLP) is negative and approaches zero as the distributional weights increase in bias towards poor or as ownership by large farmers increases. A high negative benefit to the rich ahs a low social value, and decreases further as the distributional weights increase in bias in favor of the poor. The drop in the social value of benefits accruing to rich farmers is greater than the drop in the social value of benefits received by other groups making ALP optimum in case (Table 12).

In cases (ii) and (iii) TLP and ALP are preferred to MLP primarily because of increased yield, LP cost reduction and the net gains arising from ownership of LP equipment. The first two components are positive and independent of the ownership of LP equipment. As ownership is unprofitable, the social loss is high when incurred by small farmers and outweighs the social benefits received by other groups making MLP optimum.

CONCLUSION

The present study suggests that TLP, particularly when each tractor can prepare 18 ha/season, gives a higher NPV at market prices for cultivating 133,000 ha fully irrigated sawah in Subang and Indramayu, West Java, regardless of whether yields vary across techniques or not (Table 10). When all farmers switch from MLP the anlaysis at efficiency prices shows that the optimum technique depends on the yields associated with each technique. If yields are not different among techniques MLP is optimum. Different ownership patterns of LP equipment and income distributional effect do not make any difference on the finding that the optimum technique depends on yields.

If the policy makers assume that yields do not vary across techniques, MLP should be the technique used in the area examined. However, this technique is not optimum from the individual farmer's point of view (Tables 8 and 9).

If the policy makers base their policy on the assumption that yields are different among techniques, with TLP and ALP yielding more than MLP, then the optimum technique is TLP, or ALP depending on the degree of bias of the policy makers in favor of the poor. TLP is optimum if the policy makers are not biased toward the poor and ALP when they are. These techniques are more desirable than MLP from the private farmer's point of view. One must bear in mind, however, that there is only a weak evidence supporting the hypothesis that different techniques produce different yields.

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Table 1. Distribution of sampled households.

	Wet season					Dry season					
	TF		AF	MF	Total	TF		AF	MF	Total	LL
	TO	TH				TO	TH				
Indramayu											
Sukadana	10	7	1	5	23	10	7	1	6	24	11
G. Kulon	6	8	1	4	19	1	1	1	14	17	7
Anjatan	10	3	3	5	21	10	3	3	11	27	7
Sukra	10	5	1	3	19	8	4	1	5	18	9
Subang											
B. Tengah	2	3	30	10	45	2	1	30	11	45	5
P. Hilir	9	1	2	10	22	3	1	2	13	18	7
Mariuk	8	11	10	1	30	7	2	10	2	21	7
T. Dahan	4	-	2	12	18	2	-	2	23	27	7
Total	59	38	50	50	197	43	19	50	85	197	60

Source: IRRI Mechanization Study.

Table 2. Average rice yield by village, Subang and Indramayu, West Java (in kg of dried paddy/ha).

Village	Wet season					Dry season				
	n	Ave.	Sd.	Min.	Max.	n	Ave.	Sd.	Min.	Max.
Sukadana	23	5002	968	3143	7143	24	3881	1148	667	6857
G. Kulon	19	5840	683	4000	6450	15	4360	1668	2000	8571
Anjatan	21	4790	1152	2700	7400	27	4341	1272	2286	8640
Sukra	19	4707	910	2286	6000	18	3729	1250	2535	8334
Indramayu	82	5074	1030	2286	7400	84	4082	1318	667	8640
B. Tengah	45	4756	426	4168	6276	44	2052	386	915	3080
P. Hilir	22	3834	924	2527	7000	18	3199	1576	421	6731
Mariuk	30	4886	872	3230	6857	21	2980	1025	1929	6750
T. Dahan	18	4217	538	3200	4895	27	3118	1267	1593	7931
Subang	115	4529	791	2527	7000	110	2679	1136	421	7931

Source: IRRI Mechanization Study.

Table 3. Average rice yield by farm groups and size (kg/ha)

	n	Average	Std. Dev.	Min.	Max.
Wet season					
TF, Small	7	5285	643	4186	5986
Medium	10	5451	1019	3998	6857
Large	80	4808	969	2700	7400
All sizes	97	4908	973	2700	7400
AF, Small	11	4690	311	4168	5095
Medium	17	4753	353	4323	5714
Large	22	4740	1020	2527	6470
All sizes	50	4733	712	2527	6470
MF, Small	29	4553	1123	2286	7143
Medium	10	4164	725	3143	5180
Large	11	4582	924	3266	6450
All sizes	50	4481	1009	2286	7143
All groups					
Total small	47	4694	656	2286	7143
Total medium	37	4782	826	3143	6857
Total large	113	4773	967	2527	7400
Dry season					
TF, Small	4	3287	812	2241	4225
Medium	6	3793	1386	1542	5287
Large	52	3737	1278	1992	8640
All sizes	62	3714	1252	1542	8640
AF, Small	10	2255	714	1233	3857
Medium	17	2387	702	1542	3571
Large	22	3234	1648	1600	6857
All sizes[1]	49	2740	1286	1233	6857
MF, Small	39	3210	1503	421	8334
Medium	25	3256	1458	1524	8571
Large	19	3499	1480	1821	7931
All sizes[2]	83	3290	1471	421	8571
All groups					
Total small	53	3036	1386	421	8334
Total medium	48	3015	1308	1524	8571
Total large	93	3569	1414	1600	8640

Notes: [1]One farmer did not report his yield.
[2]Two farmers did not report their yields.
Source: IRRI Mechanization Study.

Table 4. Rice yield production function.

	Wet season	Dry season
No. of respondents	197	197
R^2	0.42	0.36
$\bar{R}^2$	0.32	0.34
F value	4.02*	6.10*
Dependent variable: yield		
Independent variables:		
Intercept	3132.97 (5.56)*	2230.98 (5.89)*
Intercept dummies:		
Tractor	-594.42 (-.79)	469.58 (1.54)*
Animal	252.43 (0.31)	345.00 (1.31)*
Sukadana village	856.68 (3.09)*	421.11 (1.05)
G. Kulon village	1892.76 (4.94)*	641.95 (1.48)*
Anjatan village	802.77 (2.34)*	758.27 (2.04)*
Sukra village	836.08 (2.28)*	544.05 (1.36)*
B. Tengah village	503.88 (1.76)*	-1455.91 (-3.95)*
P. Hilir village	-501.28 (-1.86)*	19.61 (0.05)
Mariuk village	688.11 (2.09)*	-440.15 (-1.15)
Clay soil	-438.06 (-1.74)*	
Silt and sandy soil	-391.22 (-1.59)*	
Farm inputs:		
NI	-0.43 (-.16)	5.59 (2.08)*
IN	-4.36 (1.04)	8.51 (3.15)*
TSP	2.75 (1.04)	-1.14 (-.47)
LAB	8.52 (3.32)*	0.41 (0.13)
Farm size (FS)	411.00 (2.70)*	-18.44 (-.47)
Slope dummies: tractor		
NI	-0.89 (-.20)	
IN	13.00 (2.24)*	
TSP	7.33 (1.72)*	
LAB	1.86 (0.29)	
FS	-126.70 (-1.47)*	
Slope dummies: animal		
NI	-0.89 (-.15)	
IN	0.65 (0.11)	
TSP	9.82 (1.97)*	
LAB	-3.22 (-.60)	
FS	-66.66 (-.60)	
Interaction terms:		
NI (FS)	0.38 (0.50)	
IN (FS)	-0.73 (-.74)	
TSP (FS)	-1.37 (-2.64)*	
LAB (FS)	-2.37 (-2.10)*	

Notes: Base: manual land preparation technique with clay loam soil texture at T. Dahan village, Subang.

Figures in parentheses are t-values.

*Significantly different from zero employing a one-tailed t-test at 10 percent level or less.

Table 5. Estimated rice yield by farm group and farm size (kg/ha of dried paddy).

	Wet season			Dry season		
	TF	AF	MF	TF	AF	MF
Case (i)[1]						
All farms	5063	5063	5063	3472	3472	3472
Case (ii)						
Small farms	5327	5267	4633	3698	3578	3233
Medium farms	5257	5258	4691	3679	3559	3214
Large farms	5048	5229	4862	3624	3504	3159
Case (iii)						
All farms	4972	5092	4659	3647	3522	3177

Note: [1]Average of rice yields for all farm sizes in case (ii).

Table 6. NB per ha per year by each LP technique (in Rp).

	TF	AF	MF
Case (i)			
All farm sizes	508,740	508,740	508,740
Case (ii)			
Small farms	545,550	532,050	457,610
Medium farms	538,890	529,890	461,490
Large farms	519,090	523,590	470,220
Case (iii)			
All farm sizes	515,130	514,680	456,360

Source: Tables 5.19 and 5.20.

Table 7. Cost of LP per ha (Rp 000).

	Tractor	Animal	Manual
Cash only			
Wet season	(3) 24.8	(16) 24.0	(49) 24.5
Dry season	(3) 24.2	(31) 18.6	(31) 18.6
Total	49.0	42.6	43.1
Cash and meals			
Wet season	(3) 25.8	(16) 25.2	(49) 31.85
Dry season	(3) 25.2	(31) 23.25	(31) 23.25
Total	51.0	48.45	55.10

Note: Figures in parentheses are labor requirements in mandays based on an 8-hour day for TLP and MLP, and a 5-hour day for ALP.

Table 8. Annual net benefit of each LP technique derived from cultivating 1 ha of sawah for hirer farmers (Rp 000).

	Benefit	$Cost^1$	$Cost^2$	NB^1	NB^2
Case (i)					
TLP	508.74	49.0	51.0	459.74	457.74
ALP	508.74	42.6	48.45	466.14	460.29
MLP	508.74	43.1	55.10	465.64	453.64
Case (ii)					
Small farmers					
TLP	545.50	49.0	51.00	496.50	494.50
ALP	532.05	42.60	48.45	489.45	483.60
MLP	457.61	43.10	55.10	414.51	402.51
Medium farmers					
TLP	538.89	49.00	51.00	489.89	487.89
ALP	529.89	42.60	48.45	487.29	481.44
MLP	461.49	43.10	55.10	418.39	406.39
Large farmers					
TLP	519.09	49.00	51.00	470.09	468.09
ALP	523.59	42.60	48.45	480.99	475.14
MLP	470.22	43.10	55.10	427.12	415.12
Case (iii)					
TLP	515.13	49.00	51.00	466.13	464.13
ALP	514.68	42.60	48.45	472.08	466.23
MLP	456.36	43.10	55.10	413.26	401.26

Notes: Benefit = net return from cultivating one ha of sawah minus all costs except that of land preparation.

$Cost^1$ = cash cost only, $Cost^2$ = includes value of meals.

NB^1 = net benefit if $cost^1$ is used, NB^2 if $cost^2$ is used.

Sources: Tables 6 and 7.

Table 9. NPVs of benefits accruing from the ownership of the power unit and equipment of different LP techniques (Rp m).

	Small farmers	Medium farmers	Large farmers
Case (i)			
MLP[1]	1.24 (100)	3.64 (100)	10.93 (100)
ALP[2]	0.88 (71)	3.43 (94)	10.21 (93)
TLP (a)[3]	1.18 (95)	3.64 (100)	11.02 (101)
(b)[4]	0.73 (59)	3.19 (88)	10.58 (97)
Case (ii)			
MLP[1]	1.10 (100)	3.26 (100)	10.00 (100)
ALP	0.96 (87)	3.60 (111)	10.57 (106)
TLP (a)	1.27 (115)	3.88 (120)	11.27 (113)
(b)	0.83 (75)	3.44 (106)	10.83 (108)
Case (iii)			
MLP[1]	1.10 (100)	3.22 (100)	9.67 (100)
ALP	0.91 (83)	3.48 (108)	10.35 (107)
TLP (a)	1.19 (108)	3.69 (115)	11.18 (116)
(b)	0.75 (68)	3.25 (101)	10.73 (111)

Notes: [1] Not owned.

[2] Capacity = 1.88 ha/year, price of buffalo: initial = Rp160,000 per pair, selling price = Rp280,000 per pair, cost of ploughmen = Rp500 per day + meals (Rp75), cost of animal labour = Rp200 per day or Rp72,000 per year. Traditional farm implement: initial investment = Rp30,000 residual value = Rp3,000.

[3] Capacity = 18 ha/season, price of tractor Rp1,750,000, working life 7 years. Cost per ha/season: gasoline 32.5 l at Rp240/l, oil 0.75 l at Rp1,000/l, repair and maintenance Rp4,000/ha, wage of drivers Rp3,720/ha wet season, and Rp3630/ha for dry season.

[4] Capacity = 13 ha/season.

Table 10. NPV of each LP technique discounted at 10 percent. Cultivated area is 133,000 ha of sawah. Valuation is at market prices (in Rp billion).

	Case (i)	Case (ii)	Case (iii)
MLP	323.08 (100)	293.20 (100)	285.81 (100)
ALP	309.74 (96)	322.05 (110)	313.97 (110)
TLP (a)	325.66 (101)	338.40 (115)	330.21 (116)
(b)	320.97 (99)	333.72 (114)	325.52 (114)

Note: Figures in brackets are indices with MLP as base.

Table 11. NPV of each LP technique. Cultivated area is 133,000 ha of sawah. Valuation is at efficiency prices (Rp billion).

	at 6 percent	at 8 percent
Case (i)		
MLP	536.64 (100)	509.93 (100)
ALP	527.46 (98)	499.41 (98)
TLP (a)	532.88 (99)	505.95 (99)
(b)	530.21 (99)	503.21 (99)
Case (ii)		
MLP	492.73 (100)	468.21 (100)
ALP	545.56 (111)	516.62 (110)
TLP (a)	551.64 (112)	523.77 (112)
(b)	548.92 (111)	521.03 (111)
Case (iii)		
MLP	481.67 (100)	457.70 (100)
ALP	533.73 (111)	505.37 (110)
TLP (a)	539.57 (112)	512.30 (112)
(b)	536.85 (111)	509.56 (111)

Notes: Figures in brackets are indices with MLP as base.

Table 12. Rankings of LP techniques based on the present values of net social benefits.

	Case (i)				Case (ii)				Case (iii)			
	$PVNSB_0$	$PVNSB_1$	$PVNSB_2$	$PVNSB_3$	$PVNSB_0$	$PVNSB_1$	$PVNSB_2$	$PVNSB_3$	$PVNSB_0$	$PVNSB_1$	$PVNSB_2$	$PVNSB_3$
Ownership by all farms												
at 6%	ACDB	ABCD	ABCD	ABCD	CDBA	CBDA	BCDA	BACD	CDBA	BCDA	BCAD	BACD
8%	ACDB	ABCD	ABCD	ABCD	CDBA	CBDA	BCDA	BACD	CDBA	BCDA	BCAD	BACD
Ownership by small farms												
at 6%	ACDB	ACDB	ACDB	ACDB	CDBA	CDBA	CDAB	ACDB	CDBA	CDBA	CADB	ACDB
8%	ACDB	ACDB	ACDB	ACDB	CDBA	CDBA	CDAB	ACDB	CDBA	CDBA	CADB	ACDB
Ownership by medium farms												
at 6%	ACDB	ACDB	ABCD	ABCD	CDBA	CDBA	BCDA	BACD	CDBA	CDBA	BCAD	BACD
8%	ACDB	ACDB	ABCD	ABCD	CDBA	CDBA	BCDA	BACD	CDBA	CDBA	BCAD	BACD
Ownership												
at 6%	ACDB	ABCD	ABCD	BACD	CDBA	BCDA	BCDA	BACD	CDBA	BCDA	BCDA	BACD
8%	ACDB	ABCD	ABCD	BACD	CDBA	BCDA	BCDA	BACD	CDBA	BCDA	BCAD	BACD

Notes: PVNSB = present value of net social benefits, subscript indicates the distributional weights used: DW_0, DW_1, DW_2, or DW_3 for the value of the elasticity of marginal utility of income of 0, -0.5, -1.0 and -1.5 respectively.

A = MLP, B = ALP, C = TLP (a), D = TLP (b).

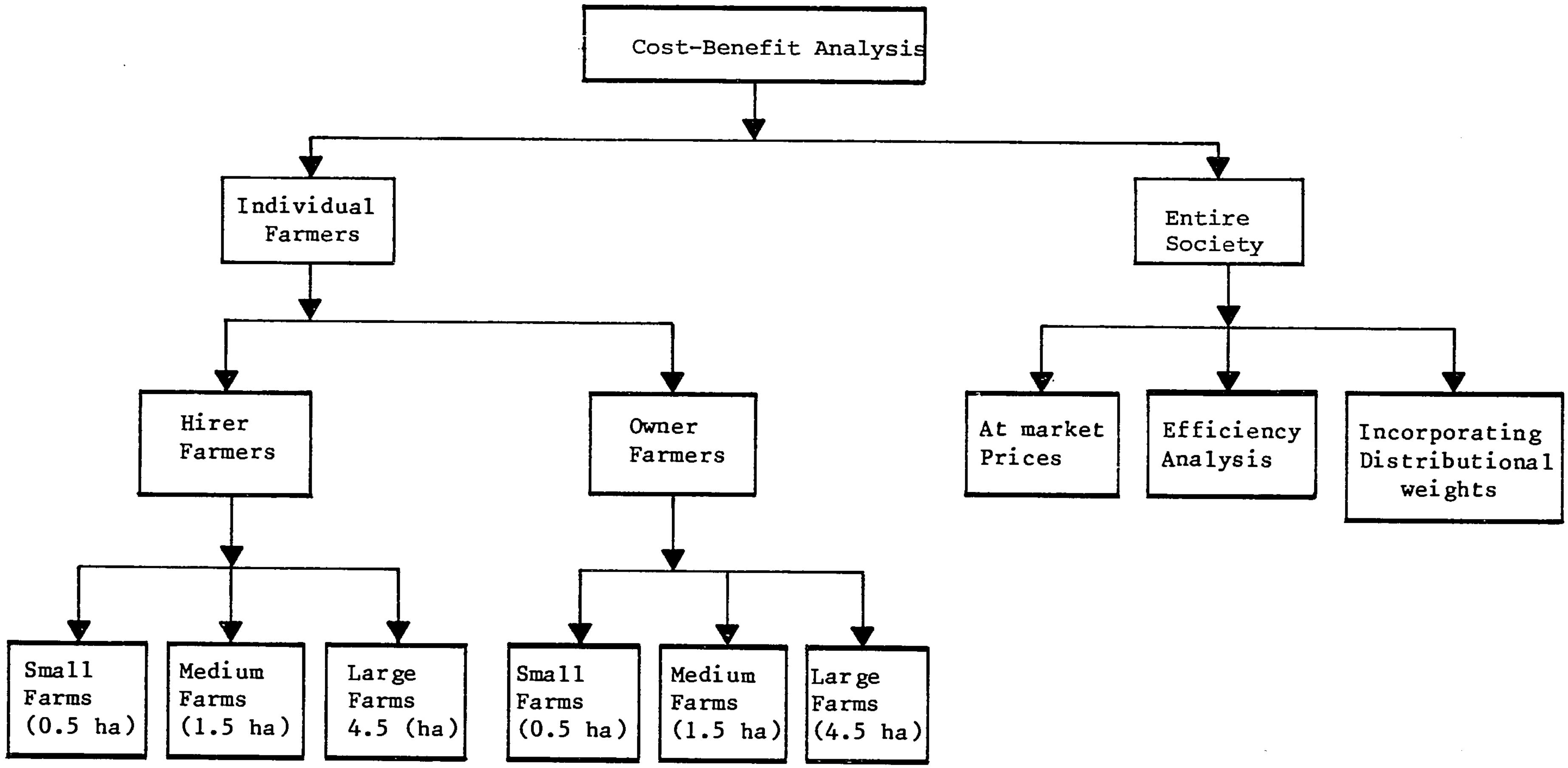

Chart 1. Levels in Cost-Benefit Analysis.