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THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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POWER TILLER USE ON RICE FARMS IN WEST JAVA, INDONESIA: AN ANALYSIS OF THEIR EMPLOYMENT EFFECTS AND PRIVATE PROFITABILITY

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ABSTRACT

This study documents the use of hand tractors in West Java, analyses their private profitability and measures some of their effects on employment. For a subsample of 61 tractor owners (43 gasoline, 18 diesel) it was found that 28 gasoline and 9 diesel tractors were operating at less than breakeven capacity. At current new purchase prices tractor ownership is not profitable. Covariance analysis was used to examine mechanization effects on employment through comparative analysis of 220 mechanized and 214 non-mechanized farms. Non-mechanized farms used more labor per hectare particularly family labor and female labor. Key variables affecting labor use were season, mechanization, farm size, fertilizer use and soil type.

INTRODUCTION

The major efforts of the Indonesian government to increase agricultural production have been through both intensification and extensification programs. Using improved technology and the mass guidance (BIMAS and INMAS) program, output per unit of land has been increased. To increase the number of crops per unit of land per annum (cropping intensity) the government has financed the construction and rehabilitation of irrigation infrastructure. During the Second Five Year Plan (1972-78) 627 thousand hectares of irrigated land were rehabilitated and new construction irrigated an additional 273 thousand hectares (Nyberg and Prabowo, 1979). At the same time the pace of agricultural mechanization, especially power tiller utilization, has significantly increased. In West Java the tractor population, especially of hand tractors, has increased by a factor of 2.7, from 431 in 1974 to 1,154 in 1978 (Saefuddin, 1980). Unlike pump-set mechanization, the tractor represents a heavily capital-intensive form of mechanization with tremendous but unproven labor-displacing potential.

As in other less developed countries, agricultural mechanization, particularly tractorization, has been the subject of widespread controversy in Indonesia. The issue has been widely and continually debated and questions occur in five key areas:

(a) Does mechanization increase farm output? If so, how?

(b) To what degree is labor displaced by these machines and what are the alternative employment opportunities for displaced labor?

(c) To what extent are the benefits of mechanization concentrated in the "less poor" sectors of society?

(d) With the rising prices of fossil fuel energy, is it still economical to mechanize?

(e) What policies should the government follow to obtain the socially desirable benefits of mechanization whilst simultaneously minimizing undesirable direct and indirect effects?

The wide divergence of opinion among researchers on the desirability of agricultural mechanization has been discussed by Gemmill and Eicher (1975) amongst others and Binswanger's seminal work reviews Indian evidence.

Our research area of Subang and Indramayu obtains water from the Jatiluhur irrigation system. In recent years, the water management system here has been improved with tertiary and quartery irrigation networks being built in each tertiary block. With such an irrigation network delivery of water is much faster (4 days) than the traditional delivery from sector to sector of rice fields which often takes up to 30 days. This has also resulted in improved efficiency of water use. The period of water availability in each irrigation block is, however, tightly scheduled and can cause problems at planting time by limiting the time available for land preparation. Land preparation labor must be rapidly mobilized to follow the water distribution schedule in each block and as a consequence the demand for labor is concentrated in a short period often making it difficult to obtain the necessary labor. The problem is also aggravated by a decrease in the draft animal/bullock population and reduced immigration of seasonal labor from outside the district (Bernsten and Rochim, 1980). This study examines some of the questions arising out of the introduction of tractors in West Java. In particular it considers whether the ownership of hand tractors is economically profitable from a private viewpoint. Also it looks at the impact of tractor mechanization on employment.

METHODOLOGY

Two different methods of analysis are used in the study.

1. Covariance analysis - is used to determine the impact of mechanization on employment or human labor use and to identify the key variables affecting labor use at the farm level. The labor used in specific farm operations (i.e. for land preparation, pulling seeds and planting, weeding and crop care, harvesting and drying) differs between tractorized and untractorized paddy rice farms and might be associated with variables other than tractorization. Such variables include season, soil type, size of farm, age and education of the farmers, and fertilizer and pesticide use. Analysis of means between

mechanized and non-mechanized farms does not separate the effects of these variables from those of tractorization. Covariance analysis, which separates the additive and multiplicative effect of these variables is, therefore, applied to the data in an attempt to account for differences in these other farm characteristics. All sample farms are irrigated and planted to modern varieties. The covariance analysis is based on the following relationships:

1) Unconstrained equation:

$$L_i = b_0 + \sum_{i=1}^{2} b_i M_i + \sum_{j=1}^{2} b_{2j} S_j + \sum_{k=1}^{2} b_{4k} W_k + b_6 H_6 + b_7 A + b_8 E + b_9 P + b_{10} N + b_{11} F + \sum_{i=1}^{2} \sum_{j=1}^{2} b_{ij} M_i S_j + \sum_{i=1}^{2} \sum_{k=1}^{2} b_{ik} M_i W_k + U_i \quad \ldots\ldots\ldots\ldots \quad (1)$$

2) Constrained equation:

$$L_i = b_0 + \sum_{i=1}^{2} b_i M_i + \sum_{j=1}^{2} b_{2j} S_j + \sum_{k=1}^{2} b_{4k} W_k + b_6 H + b_7 A + b_8 E + b_9 P + b_{10} N + b_{11} F + V_i \quad \ldots\ldots \quad (2)$$

Dependent variables

L_i = refers to the level of human labor used in specific farm operations (i.e. land preparation, planting, weeding and nursery labor, etc.) in man hours.

Independent variables:

M_i = mechanization dummy; this takes a value of unity if the farm is mechanized (tractor-owning and tractor-hiring farms) and a value of zero otherwise (manual/hoeing farms).

S_j = soil condition dummy based on soil texture. It takes a value of unity if the soil is a clay or clay loam (heavy cultivated soil), and a value of zero otherwise (easily cultivated soil).

W_k = season dummy; takes a value of unity for the musim hujan (wet season 1979/1980) and zero for the musim kemaru (dry season, 1980).

H = size of landholding measured as the total lowland holding of the farmer in hectares.

A = age of the farmer in years. Younger farmers are expected to have a greater physical endurance for farming and may also be readier adopters of new technology.

E = education measured in the number of years the farmer has attended formal school. Educated farmers are expected to have better technical and managerial information.

P = farm experience in the number of years the farmer has managed his own farm.

N = potential family labor available given by the number of family members 10 years old and above. The higher the potential family labor available, the less the likelihood that the farmer will use tractors and the higher will be labor use per hectare.

F = value of fertilizer used expressed in rupiah (Rp).

b_0 = intercept

b_i, b_j and b_k = parameters

U_i and V_i = disturbances or statistical error terms.

Covariance analysis also permits investigation of the multiplicative effects between independent variables (e.g., interactions between mechanization dummy (Mi) and soil condition dummy (Sj), mechanization dummy (Mi) and season dummy (Wk). To test for the statistical significance of the interactive effect, the F-statistic based on the residuals of the estimating unconstrained equation (i.e., with variables $M_i S_j$ and $M_i W_k$) and constrained equation (i.e. without variables $M_i S_j$ and $M_i W_k$) is used. The null hypothesis is that H_o: $b_{ij} = 0$ (null hypothesis, the regression slope of interaction variables M_i and S_j equal to zero), against the alternative hypothesis H_a: if H_o is not true, or that $b_{ij} \neq 0$. The F-statistic is computed as follows:

$$F_{r\,N-K} = \frac{(\sum V_i^2 - \sum U_i^2)/r}{\sum U_i^2 / N-K} \quad \ldots \quad (3)$$

where:

V_i^2 = residual sum of squares of the constrained equation

U_i^2 = residual sum of squares of the unconstrained equation

r = number of restrictions

N = number of observations

K = number of regressors or independent variables

$r, N-K$ = degrees of freedom (df)

If $F'_{r, N-K}$ calculated is greater than F table value, the null hypothesis (H_o), is rejected and the alternative hypothesis H_a is accepted. If $F'_{r, N-K}$ is less than F table value, the null hypothesis is accepted and the alternative hypothesis (H_a) is rejected.

2. Private profitability analysis. To evaluate private profitability of hand tractor operations, benefit-cost ratios (B/C), net present values (NPV), internal rates of return (IRR), and break-even point (BEP) analyses are calculated.

Two alternative buying prices of the tractor are used for each analysis. Buying price I is the actual price derived from the survey data, or the average buying price when the tractors were bought. Buying price II is the current (1981) purchase price of a new tractor ready for use.

Tractor benefit and cost analysis. This analysis is divided into two groups: gasoline and diesel tractors. The analyses, which are strictly financial/private analyses are shown below for benefit-cost ratios (B/C), net present values (NPV) and internal rates of return (IRR).[1]

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

$$NPV = B - C = \sum_{t=0}^{n} \frac{B_t}{(1+r)^t} - \sum_{t=0}^{n} \frac{C_t}{(1+r)^t} \quad \ldots \quad (5)$$

$$IRR = B - C = \sum_{t=0}^{n} \frac{B_t}{(1+r)^t} - \sum_{t=0}^{n} \frac{C_t}{(1+r)^t} = 0 \quad \ldots \quad (6)$$

and

B_t = benefit occurring in year t

$B = B_1 + B_2 + B_3$

B_1 = benefit from own farm land cultivated per year; this is measured as the total area of the own farm cultivated by tractors multiplied by the average custom rate per hectare for the respective groups of tractors (gasoline or diesel) in rupiah. In other words, we are assuming that the farmer would have to hire a tractor in the absence of owning one himself.

B_2 = benefit of off-farm land cultivated per year computed as the area of off-farm land cultivated times the custom rate per hectare received by the tractor owner. This benefit is the total returns from hiring the tractor measured in rupiahs.

B_3 = salvage value of the tractor in rupiah. This benefit is realizable only in the last year of the economic life of the hand tractor.

C_t = cost incurred in year t

$C = NC + VC$ where $VC = U + O + R + L$

NC = initial cost defined as capital outlay in buying a tractor

VC = variable cost per year expressed in rupiah - the sum total of expenditures per year on diesel or gasoline fuel used (U), oil/lubricants used (O), repair and maintenance costs (R) and the labor costs of the operator (L)

t = index of the tth year

n = number of years involved (n=1, 2, ..., 6)

r = discount rate

The assumptions used in the analysis are:

1. Flows of benefits and variable costs are the same for each year of economic life of the tractor.

2. The expected economic life of a hand tractor is 6 years.[2]

3. Salvage value of the tractor is 10 percent of capital investment.

4. The discount factor on capital investment is 12 percent per year[3]

Tractor breakeven point analysis. The breakeven point is the number of hectares of land cultivated or the custom rate to be charged which is just sufficient to cover the total annual costs of the tractor (fixed and variable costs). This is computed on an annual per-hectare basis. The analysis is carried out for both gasoline and diesel tractor groups. The formula used to calculate the breakeven point is presented below:

$$(T) \times (B) = FC + VC \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

where:

B = area served in hectares defined as total area of cultivated land just sufficient to cover the operating of the tractor.

T = custom rate in rupiahs per hectare computed as the average custom rate of the respective tractor group.

FC = fixed cost in rupiah per annum defined as the sum total of depreciation (D) and interest on capital investment (I).

VC = variable cost also expressed in rupiah per annum as previously defined.

THE STUDY AREA/DATA COLLECTION/SITE DESCRIPTION

a. The study area and selection of the farmers. The surveys were conducted in the districts of Subang and Indramayu, in the province of West Java (Fig. 1). In each district, three subdistricts with the greatest number of hand tractors were randomly selected. Four villages with four or more farmers owning tractors were selected in each district. Before choosing the sample of farmers, a block census was carried out in eight villages covering 1,600 households. Census respondents were grouped according to the power used for primary tillage in the wet season of 1978/1979. The six stratified groups were: 1) tractor owner farmers; 2) tractor hiring farmers, 3) animal-hoeing farmers, 4) manual/hoeing farmers, 5) tractor-animal farmers, and 6) field laborers. By using proportionate random sampling from each census block, sample households were chosen.

This study uses data for the wet season 1979/1980 and dry season 1980, with three groups of farmers (hand tractor owner farms, hand tractor hired farms and manual/hoeing farms). The six subdistricts

and eight villages selected and the number of the respective group samples for the two seasons are presented in Table 1.

b. Source of data and its limitations. The data used for this study were collected as part of the study entitled "The Consequences of Small Rice Farm Mechanization Project in Asia", conducted by the International Rice Research Institute (IRRI). Farm level primary data were collected through a series of cross sectional surveys and a complementary daily record keeping system, for two crop years. Two sites in Indonesia were chosen for this study: West Java and South Sulawesi province. The present comparative study uses data pertaining only to West Java.

All the information, both farm level primary data and complementary daily records, were collected based on the farmers' recall. Farmers have not established farm record systems and have difficulty in accurately recalling information. In addition because of possible taxation considerations there may be a tendency for farmers to over-estimate costs and underestimate returns.

The two districts were selected because farmers in the area were early adoptors of tractors and used about 32 percent of total tractor horsepower consumption of the 20 districts of West Java. They are also major rice-producing areas and well irrigated. In 1978, the number of hand tractors reached 137 units or about 934 H.P. in Subang. In Indramayu hand tractors numbered 260 units, totalling 1,889 H.P. The most common brands used by farmers in the area were Kubota, Honda, Patra and Yanmar.

c. Social features. The household heads of tractor owning farms were older, had more schooling and farm experience than those of tractor hiring farms and manual/hoeing farms. Family size and potential family labor (family members 10 years old and above) of the three types of farms did not vary greatly during the wet and dry seasons. Manual/hoeing farms had the highest real family labor (defined as the number of family members who work on their own farms) compared to the real family labor of other types of farms (tractor owner farms and tractor hired farms). During the wet season, real family labor of manual/hoeing farms, tractor owner farms and tractor hired farms were 1.65, 1.10 and 1.07 persons respectively. Real family labor was 1.51 persons for manual/hoeing farms, 1.16 persons for tractor owner farms and only 1.02 persons for tractor hiring farms during the dry season.

For tractor owner farms, permanent labor, (labor hired on contractual basis for a certain period of time) had a more important role in farm operations than on the two other types of farms. This is because the tractor driver may be the only permanent male labor on tractor owner farms. Sometimes he will take the place of the

household head in supervising field workers (hired labor) in farm operations. Permanent female labor serves as household help, nursing the children and preparing meals for family members and field workers. Farmers who owned cattle usually used their children to feed or tend the cattle. Permanent laborers were mostly paid seasonally or annually in kind (paddy rice), aside from provisions (i.e. food, clothing and shelter). The existence of permanent labor on farms is clearly related to the level of prosperity of the farmer. Permanent labor was 0.79 persons for tractor owner farms, 0.08 and 0.09 persons for tractor hired farms and manual/hoeing farms, respectively, during the wet season. In the dry season these figures were 0.84, 0.15 and 0.14 persons, respectively.

d. Economic features

i) Farm size and tenure. Landholding defined as the total of land owned and net rented in and out was related to the type of farm. In general the higher the level of mechanization, the larger the landholding. The same trend applies to operated land. This might be based on the fact that more income can be derived from larger farms (primarily from rice sales) to finance the purchase of tractors. Landholding and operated land differed significantly among the three types of farms.

Based on land tenancy of all operated parcels of sample farms, a farmer can be classified as either an owner operator, part owner operator, lessee operator, or a share cropping operator. More than two-thirds of the farmers on tractor owner farms and tractor hiring farms were owner operators. The remaining third were part owner, lessee, share croppers and others. For manual/hoeing farms, about 60 percent of the total land holders consisted of owner-operators. The second largest landholder category after owner operators was lessee operator for both tractor owner farms and tractor hired farms and share cropper operator for manual/hoeing farms.

ii) Improved input use and yield. Improved inputs include high yielding variety (HYV) seeds and chemical fertilizer and pesticides such as herbicides, insecticides, and rodenticides. The most common seeds used by farmers in the study were C4-63, IR26 and IR28. Types of fertilizer used were single fertilizer, urea fertilizer (40 to 45% N) and triple superphosphate (TSP). Sevin, Furadan, Thiodan, Gamma BHC and Basudin were pesticides commonly used on the farms.

More fertilizer was used during the wet season than during the dry season, while seed and pesticide use was less during the wet season compared to the dry season for all types

of farms. During both seasons, tractor hiring farms had the highest fertilizer use. Fertilizer consumption during the wet season was 341 kg per ha broken down into 251 kg of urea and 90 kg TSP. During the dry season, total fertilizer used by tractor hiring farms was 313 kg (233 kg urea and 80 kg TSP). Mechanized farms had higher yields per ha than non-mechanized farms during the dry season. This cannot however be solely attributed to mechanization, since almost 24 percent of the nonmechanized farms harvested crops from only 50 percent of the area planted due to extensive damage by rats and stemborers. The difference in yield between mechanized and non-mechanized farms, however, is insignificant during the wet season. Apparently, the highest yield per ha attained by tractor hired farms is not due to the level of mechanization but primarily due to massive fertilizer use during both seasons. Mechanized farms (tractor owner and tractor hired farms) have slightly higher yields per ha compared with non-mechanized (manual/hoeing) farm.

iii) Patterns of Labor Use. Mechanization has changed the pattern of labor use in terms of both the source and the type of labor. During the wet season, nonmechanized farms used a total of 1,691 hours per hectare, while tractor owner farms and tractor hiring farms used only 1,034 and 1,205 hr per ha, respectively. The corresponding figures are 1,186 hr, 996 hr and 1,609 hr per ha for manual/hoeing farms, tractor owner farms and tractor hiring farms, respectively, during the dry season. Based on total human labor used, evidence supports the hypothesis that mechanization replaces human labor especially at the land preparation stage. In terms of source of labor, on mechanized farms family labor constitutes only 5 to 11 percent of the total human labor used. The remainder is hired. On nonmechanized farms family labor makes up 23 to 26 percent of total labor use. Tractor owners and tractor hiring farms used almost the same proportions of male and female labor. For manual/hoeing farms, however, male labor per ha is higher than female labor. The proportion is about 60 percent.

RESULTS

a. Tractor ownership survey. Gasoline tractor owners (46) stated that they found machines cheaper in land preparation whilst for diesel tractor owners (18) their main reason in using a machine was that it enabled them to plant on time.

The average age of gasoline tractors was 2.06 years and for diesel tractors 1.75 years. Fifty percent of both sample groups had a machine size of 7 horsepower. In terms of the area served, both types

of tractor were used less on the owner's farm than off-farm. The area served per year averaged 23.9 hectares for diesel tractors and 20.7 hectares for gasoline tractors.

b. Private profitability analysis. Two analyses were conducted to determine the profitability of tractor ownership: benefit-cost analysis and break-even analysis. Benefit-cost analysis calculates the benefit-cost ratio (B/C), the net present value (NPV) and internal rate of return (IRR). Break-even analysis refers to the computation which equates costs and returns based on a simulated average cost curve. Two alternative buying prices of tractors were used for each analysis. Buying price I is the price derived from the survey data, or the average buying price of a sample tractor. The average price is Rp 783,600 for a gasoline tractor and Rp 1,360,179 for a diesel tractor. Buying price II is the current buying price of a new tractor ready for use: Rp 1,500,000 for a gasoline tractor and Rp 3,000,000 for a diesel tractor.

Results of the benefit-cost analysis are summarized in Table 2. At buying price I both types of tractor are still profitable to operate as denoted by their positive net present values (NPV), benefit-cost ratios (B/C) greater than unity and internal rates of return (IRR) higher than the opportunity cost of the capital (12%). Conversely, ownership of both types of tractor, at buying price II, is not profitable. Based on actual area served, the profitability of tractor ownership is very sensitive to the buying price, but only slightly affected by the discount factor.

The results of the profitability analysis using buying price II should be treated with appropriate caution. In particular, two specific points should be borne in mind. First, there is suspicion of bias in the computation procedure. Net present values (NPV), benefit-cost ratios (B/C) and internal rates of return (IRR) obtained using the survey data may be underestimated. The benefit from a new tractor should be higher than that of the old one because of the potentially larger area served by the new tractor. On the other hand, average variable costs of a new tractor could be lower than those of an old one because of the lower cost of repair and maintenance and more efficient use of fuel and oil/lubricant of new machines. Second, although from the private economic viewpoint the ownership of a tractor seems unjustified, it may still be socially worthwhile, compared to farmers spending their earnings from rice sales for unproductive consumption purposes, e.g. motorcycle, a television set, a tape recorder, or to entertain guests during the fiesta. Furthermore, several farmers with larger farms considered ownership of a tractor as a source of pride and prestige and derived consumption benefits from their ownership in the form of transport, etc. Such factors are not incorporated in the analysis.

There does, however, appear to be an oversupply of tractors at prevailing custom-hire rates, tractor prices, interest rates and fuel costs. Adjustment in this market could take many forms dependent upon the competitive forces and surpluses accruing in these input markets. Cost items might fall in price in response to falling demand but it seems most likely that the apparent disequilibrium in the tractor hiring industry will to a large extent be removed by contractionary market forces. Some tractor owners will not replace their assets having had difficulty repaying their previous loans. Area served for a smaller number of tractors might rise, custom-hire rates go up and a competitive market equilibrium occur where all tractor-owners earn normal profits and all costs are just covered. Such a long term adjustment mechanism will, however, be a somewhat inefficient and painful one and government intervention may be necessary to iron out some of the fluctuations. Maranan (1981) observed similar behaviour in the Philippines power tiller industry.

Cost Curve Analysis

Results of a cost curve analysis are presented in Figures 2 and 3. These cost curves were derived from fixed and variable costs for operating both types of tractors. To obtain the figures used in plotting the curves, each tractor's total fixed cost (based on buying price I and buying price II) was divided by the area served, then added to the average variable cost (AVC). The resulting figures are expressed as average total cost (ATC) per hectare. For example, total fixed cost for gasoline tractor based on buying price I is Rp 350,926. For the case in which the area served is 8 hectares, Rp 350,926 was divided by 8 hectares to obtain average fixed cost (AFC) per hectare served, i.e. Rp 25.271. To this value was added the average variable costs of gasoline tractors (Rp 11,932), and the resulting figure obtained, Rp 37,203 is the average total cost (ATC) per hectare. Cost curves represent the relationship between the area served and ATC per hectare. The curves are convex to the origin - the larger the area served by the tractor, the greater the reduction in cost per hectare.

Based on the actual/existing custom rate, the break-even area served by gasoline tractors is 22.3 hectares and 42.7 hectares per year, using buying price I and buying price II respectively. Similarly, the break-even area served is 25.1 hectares and 55.4 hectares per year for buying price I and buying price II, respectively, for a diesel tractor. On the other hand, if the actual area served is maintained, it would be necessary for gasoline tractor owners to charge Rp 21.7 thousand per hectare to cover all costs based on buying price I and Rp 30.6 thousand, based on buying price II. Similarly, for diesel tractors break-even custom rates of Rp 23.7 and Rp 41.4 thousand would be necessary at buying price I and buying price II respectively, to cover all costs (Table 3).

c. Covariance analysis. For human labor used in specific farm operations, i.e. land preparation labor, weeding and nursery labor, total labor and the value of total labor are significantly different at the 1 and 5 percent level between mechanized and non-mechanized farms. Such differences were further analyzed using covariance analysis. The results of the covariance model are presented in Tables 4 to 6. Regression I is the unconstrained model which incorporates the interaction terms. Regression II is the constrained/non-additive model without interaction term. F-tests show that interaction terms (MS and MW) are statistically significant (at 5 percent level) for regressions explaining the variation in land preparation labor, total labor and value of total labor. However, the interactive influences were found to be statistically insignificant for weeding and nursery labor (unreported).

The value of the coefficient of determination (R^2) obtained from the analyses is smaller than 50 percent. It indicates that less than 50 percent of the variation in labor use can be attributed to the selected explanatory variables. Judging from the corrected coefficients of determination ($\bar{R}^2$), regression I (additive model) is better than regression II. However, for discussion purposes both regressions are used. Furthermore, the results of the analysis show that there is multi-collinearity between season (W) and interaction term, mechanization and season (MW) (r=0.75), and between age (A) and farm experience (P) (r=0.85).

Results from the covariance analysis revealed that mechanization has a significant negative effect on land preparation labor and total labor use per hectare. In other words, mechanization decreases labor used in land preparation and total labor use. Labor use per hectare in land preparation and total labor use by mechanized farms in regression I were respectively 156.02 and 166.05 hours lower than those of nonmechanized farms. In regression II, the corresponding figures are 212.15 and 207.43 hours. Although its effect is insignificant, mechanization had a negative effect on weeding and nursery labor and on the value of total labor. Furthermore, the findings show that in addition to the mechanization dummy, the other key variables affecting land preparation labor are season and the interaction term between season and mechanization, potential labor and value of fertilizer used. The major variables that affect total labor use are season and its interaction with mechanization, size of landholding, farmer's education, potential labor, value of fertilizer used and interaction term between mechanization and soil condition.

POLICY IMPLICATIONS

In the study area, labor shortages, primarily in land preparation, appear to be a binding constraint for the larger

rice-producing farms. Since the period of water availability is tightly scheduled, the time available for land preparation labor is concentrated in a short period and it is sometimes difficult to get necessary labor.

Two approaches to this problem can be used. The first is to increase the mobility of existing labor through an improved flow of labor market information in order to better equalize demand and supply over space and time. Wage rises for peak periods could perform this function. In designing an appropriate policy regarding mobilization of existing labor, however, in-depth research must be carried out concerning the demand-supply pattern of agricultural labor, season by season at least at the kecamatan (sub-district) level and preferably at the kabupaten (district) level.

As a second approach, it may be necessary to increase the land preparation power capacity of the study area through the introduction of more draft animals and mechanical power. This seems difficult. At present the condition is not favorable to draft animals, primarily because of a large decrease in available grazing areas. Often the only available grazing is in forest suburb areas which are some distance from the farm owner's residence. This situation causes difficulties in both animal care and control. Animals are often stolen, and wages for permanent labor for feeding or tending the animals are expensive. Another problem is the threat of the irrigation authority and village officials to impose fines on farmers who let their animals wallow in the irrigation canals and roam on village road, especially during the wet season.

Therefore, the introduction of selective mechanical power/ tractorization could be appropriate in increasing land preparation power capacity. The government should provide guidance in the adoption of farm machinery in such a way that tractorization would intensify and expand output in the agricultural sector. Recent data on the tractor population shows a continuously increasing trend without preferential credit facilities. This is supported by the fact that of 68 sample tractor owners, only 7 bought tractors through formal credit facilities (government banks) and nonformal sources (money lender, their family, etc.). The real question, therefore, is perhaps not whether farms are to be mechanized or not but how should mechanization be carried out? The findings suggest that tractor ownership should not be restricted to larger farmers since many of them already have a sufficiently large area to employ a hand tractor.

The point to be borne in the policy maker's mind is how to set up some short term interim guidelines to minimize if not eliminate the undesirable labor-displacing side-effects of mechanization. Policy measures can be implemented as follows: First, the tractorization

program should consider shortage of labor by season (busy and idle time), location (densely or non-densely populated area in relation to availability of labor), and size of farm (larger farms more often have shortages of labor than smaller farms). In popular usage, this is called a "Selective Mechanization Program". Secondly, the adoption of tractorization should be steered along an "intensification" pathway. Thus, mechanizing farmers should increase their cropping intensity (i.e., double or triple cropping) on their existing cultivated area (McInerney and Donaldson, 1975). If mechanizing farmers are in some way constrained from expanding farm size beyond a minimum efficient level, then they will be more inclined to seek these intensity increases (either on their own farms or they may hire out tractor services to neighboring non-mechanized farms) as the only means to make their capital investment economically justified. Otherwise, mechanization follows the wrong route called the "extensification pathway". This means mechanizing farmers expand their annual cropped area by taking over the land already cultivated by another farmer.

To prevent or at least minimize displacement of human labor, machinery should be introduced together with "an improved package" such as improved seed, fertilizer, pesticide, irrigation, and better management. This "package deal" should increase human labor use and even lead to the creation of employment opportunities. In other words, mechanization is just one part of a technology choice complex and availability of a full array of complementary inputs must be ensured.

With regard to the private profitability of tractor ownership at buying price I, both types of tractors are still profitable to operate. The results of profitability analysis, using buying price II which shows that tractor ownership is not profitable, should be interpreted carefully. First, there is a suspicion of bias in the computation procedure. Secondly, from the sociocultural viewpoint, instead of farmers spending their money from rice sales on consumer purposes, it might be better for them to spend it on a productive purpose such as a tractor. Although from the private economic viewpoint it appears unjustified, still it may be socially worthwhile long run alternative. The constraints or deterrents to unnecessary consumption expenditure purposes might be, for example, some form of progressive tax on durable goods ownership beyond a certain need, or a high fee to permit farmers to hold fiestas more than a certain number of times within a year. However, availability of consumer goods may be necessary to induce output responses from farmers.

To make tractor ownership economically justified, two policy measures are suggested. On the ownership side, if mechanizing farmers are in some way constrained from expanding farm size beyond a minimum level or cannot reach break-even point for the area served, joint

ownership and operation of one hand tractor by two or three farmers is advisable. This cooperation can be carried out primarily through kinship. On the other hand, the operational problems related to mechanization should be given immediate and proper attention by coordinating government agencies (agriculture, credit, industries and manpower agencies) and private agencies (i.e. tractor dealers) in establishing and directing workshop facilities. Presently, tractor owners must go to Karawang (the nearest district capital from the study area), Bandung (provincial capital) and Jakarta (capital of Indonesia) to buy spare parts. Workshop facilities with adequate space, technical personnel and stocks and spare parts should be established strategically in Subang, Indramayu and Pamanukan. A policy framework to prevent or minimize undesirable effects of mechanization on casual and displacement labor, especially landless labor, should also be considered and the effects on employment at both the regional and national levels should be evaluated.

FOOTNOTES

[1]See J. Price Gittinger, "Economic Analysis of Agricultural Projects," The Economic Development Institute, International Bank for Reconstruction and Development, John Hopkins University Press, Baltimore, London, 1972, pp. 61-98.

[2]The expected economic life of the hand tractor was estimated as 6 years based on two considerations: first, the distribution of the ages of the sample tractors in this survey varied from 0 to 9 years. Second, from the technical point of view, a hand tractor cannot realiably be used after 6 years.

[3]The interest rate for credit facilities from government categorized as K.I.K. (credit for small investment) which includes a tractor is 10.5 percent per year or 0.8 percent per month. In addition the borrower is charged an undefined administrative cost, estimated at 0.5 to 1.0 percent of the total credit advanced.

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Table 1. Subdistrict and village sample and number of sample farmers in each group and each season.

A. Subdistrict and village sample of the study area.

DISTRICT	SUBDISTRICT	VILLAGE
1. Subang	1. Pusakanagara	a. Bojong Tengah
	2. Pamanukan	b. Pamanukan Hilir
	3. Binong	c. Mariuk
		d. Tambak Dahan
2. Indramayu	1. Bangodua	a. Sukadana
	2. Gabus Wetan	b. Gabus Kulon
	3. Anjatan	c. Anjatan
		d. Sukra

B. Number of sample farmers in each group and each season.

GROUP (Power Source for Primary Tillage)	Wet Season 1979-80	Dry Season 1980	TOTAL
1. Hand tractor owned farmers	68	64	132
2. Hand tractor hiring farmers	49	39	88
3. Manual/hoeing farmers	56	158	214
Total	173	261	434

Table 2. Benefit-cost ratios (B/C), net present values (NPV) and internal rates of return (IRR) for operation of sample tractors.

Item	Gasoline tractor (N=43)		Diesel tractor (N=18)	
	Undiscounted	Discounted 12%	Undiscounted	Discounted 12%
1. Benefit cost ratio (B/C)				
1.1 Buying price I[a]	1.19	1.02	1.29	1.04
1.2 Buying price II[b]	0.93	0.74	0.84	0.62
2. Net present value (NPV) Rp				
2.1 Buying price I[a]	421.548[c]	28,352	782,413[c]	83,955
2.2 Buying price II[b]	-223,212[c]	-651,727	-693,426[c]	-1,472,727
3. Internal rate of return (IRR)%				
3.1. Buying price I[a]	13.25		14.11	
3.2 Buying price II[b]	<1[d]		<1[d]	

[a]Buying price I is the average buying price of a sample tractor. The buying price is Rp 783,600 and Rp 1,360,179 for gasoline and diesel tractors respectively.

[b]Buying price II is the current buying price of a new tractor ready for use. This is Rp 1,500,000 for gasoline tractors and Rp 3,000,000 for diesel tractors.

[c]In strict usage, this figure represents net benefit (NB) instead of net present value (NPV).

[d]This means that the IRR is less than the opportunity cost of the capital of 12%.

Table 3. Break-even area served and custom rate for operation of sample tractors.

Item	Gasoline tractors			Diesel tractors		
	Buying price I[a]		Buying price II[b]	Buying price I		Buying price II
1. Based on actual custom rate						
1.1 Break-even area served (ha/year)	22.28		42.66	25.12		55.41
1.2 Actual area served (ha/year)		20.70			23.94	
1.3 Differences (ha/year)[c]	-1.58		-21.96	-1.18		-31.47
2. Based on actual area served						
2.1 Break-even custom area (Rp/ha)	21,669		30,628	23,697		41,369
2.2 Actual custom rate (Rp/ha)		21,004			23,007	
2.3 Differences (Rp/ha)[c]	-695		-9,624	-690		-18,362

[a]Buying price I is average buying price of the sample. The buying prices are Rp 783,600 and Rp 1,360,179 for gasoline and diesel tractors respectively.

[b]Buying price II is 1981 purchase price of new tractor ready for use. These are Rp 1,500,000 for gasoline tractors and Rp 3,000,000 for diesel tractors.

[c]Between actual custom rate and break-even custom rate.

Table 4. Results of covariance analysis on human labor used in land preparation (hr/ha

Independent variables	Dependent Variable	
	Regression I	Regression II
Intercept	125.709*** (49.879)[a]	135.837*** (47.666)
(M) Mechanization	-156.016*** (30.378)	-212.148*** (20.083)
(S) Soil condition	- 8.041 (24.845)	15.268 (17.402)
(W) Season	218.662*** (25.379)	94.340*** (17.376)
(H) Size of landholding	- 1.707 (2.941)	- 1.850 (3.048)
(A) Age of farmer	- 0.783 (1.290)	- 0.405 (1.341)
(E) Farmer's education	- 3.299 (2.424)	- 3.757 (2.494)
(P) Farm experience	0.784 (1.459)	0.306 (1.525)
(N) Potential labor	1.265*** (0.281)	1.201*** (0.294)
(F) Value of fertilizer used	6.753*** (1.267)	6.806*** (1.325)
(MS) Interaction term mechanization-soil condition	34.701 (33.147)	NA
(MW) Interaction term, mechanization-season	-213.993*** (33.139)	NA
(R^2) Coefficient of determination	0.429	0.372
($\bar{R}^2$) Corrected coefficient of determination	0.414	0.358
(N) Number of observations	429	429

Table 4 (continued)

NA = not applicable

[a]Figures in parentheses are standard errors of the estimated coefficients.

*Significant at 10% level.

**Significant at 5% level.

***Significant at 1% level.

F_{r}, N-K (Computed "F" ratio with 2 and 420 degrees of freedom = 21.26 greater than F table (significant at 5% level) = 3.02.

Table 5. Results of covariance analysis on total human labor (hr/ha).

Independent variables	Dependent variable	
	Regression I	Regression II
Intercept	817.705*** (157.184)[a]	762.191*** (146.726)
(M) Mechanization	-166.052* (95.651)	-207.434*** (61.759)
(S) Soil condition	-90.512 (78.320)	28.921 (53.526)
(W) Season	478.457*** (80.004)	213.607*** (53.477)
(H) Size of landholding	-21.714** (9.172)	-22.354** (9.376)
(A) Age of farmer	- 1.216 (4.066)	0.122 (4.132)
(E) Farmer's education	-13.078* (7.631)	-12.293* (7.67)
(P) Farm experience	2.373 (4.600)	1.152 (4.698)
(N) Potential labor	4.558*** (0.885)	4.394*** (0.905)
(F) Value of fertilizer used	22.693*** (3.994)	23.081*** (4.081)
(MS) Interaction term, mechanization-soil condition	198.122** (104.403)	NA
(MW) Interaction term, mechanization-season	-451.665*** (104.359)	NA
(R^2) Coefficient of determination	0.268	0.230
($\bar{R}^2$) Corrected coefficient of determination	0.249	0.214
(N) Number of observations	430	430

Table 6 (continued)

N.A. = not applicable

[a]Figures in parentheses are standard errors of the estimated coefficients.

*Significant at 10% level.

**Significant at 5% level.

***Significant at 1% level.

F_{r}, N-K (computed "F" ratio with 2 and 421 degrees of freedom) = 6.80 greater than F table (significant at 5% level) = 3.02.

Table 6. Results of covariance analysis on value of total human labor (000 Rp/ha).

Independent variables	Dependent variable	
	Regression I	Regression II
Intercept	98.162*** (16.477)[a]	93.258*** (15.237)
(M) Mechanization	-8.554 (10.027)	-11.610* (6.413)
(S) Soil condition	-22.728*** (8.210)	-12.593** (5.558)
(W) Season	37.004*** (8.387)	15.210*** (5.553)
(H) Size of landholding	-2.032** (0.961)	-2.987** (0.974)
(A) Age of farmer	-0.575 (0.426)	-0.463 (0.429)
(E) Farmer's education	-0.939 (0.800)	-0.867 (0.797)
(P) Farm experience	0.680 (0.482)	0.578 (0.488)
(N) Potential labor	0.448*** (0.093)	0.435*** (0.094)
(F) Value of fertilizer used	2.615*** (0.419)	2.649*** (0.424)
(MS) Interaction term, mechanization-soil condition	16.854 (10.944)	NA
(MW) Interaction term, mechanization-season	-37.154***	NA
(R^2) Coefficient of determination	0.225	0.200
($\bar{R}^2$) Corrected coefficient of determination	0.205	0.183
(N) Number of observations	430	430

Table 5 (continued)

N.A. = not applicable

[a]Figures in parentheses are standard errors of the estimated coefficients.

*Significant at 10% level.

**Significant at 5% level.

***Significant at 1% level.

F_r, N-K (computed "F" ratio with 2 and 421 degrees of freedom) = 10.92 greater than F table (significant at 5% level) = 3.02.

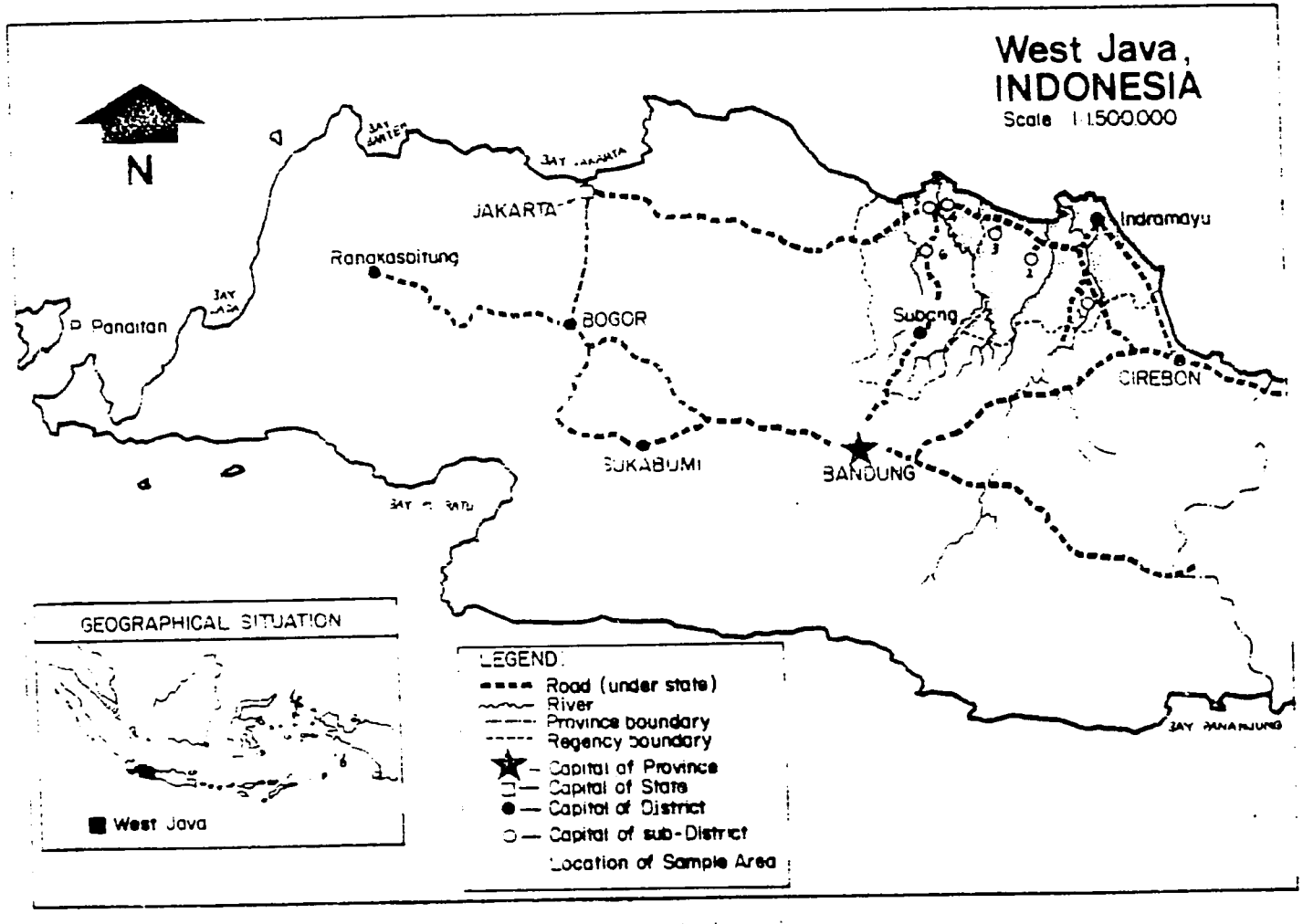

Figure Location of sample area West Java, Indonesia

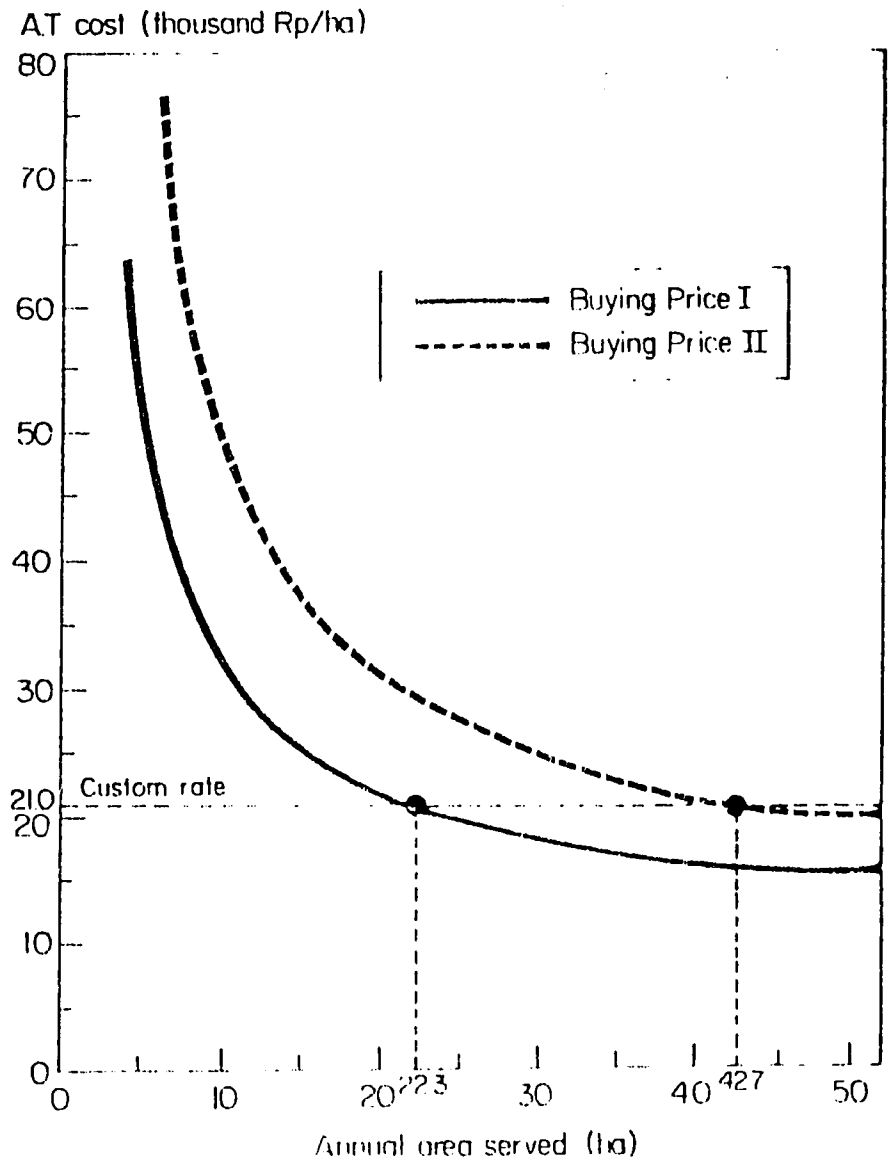

Figure 2. Cost curve-area served relationship for a gasoline tractor.

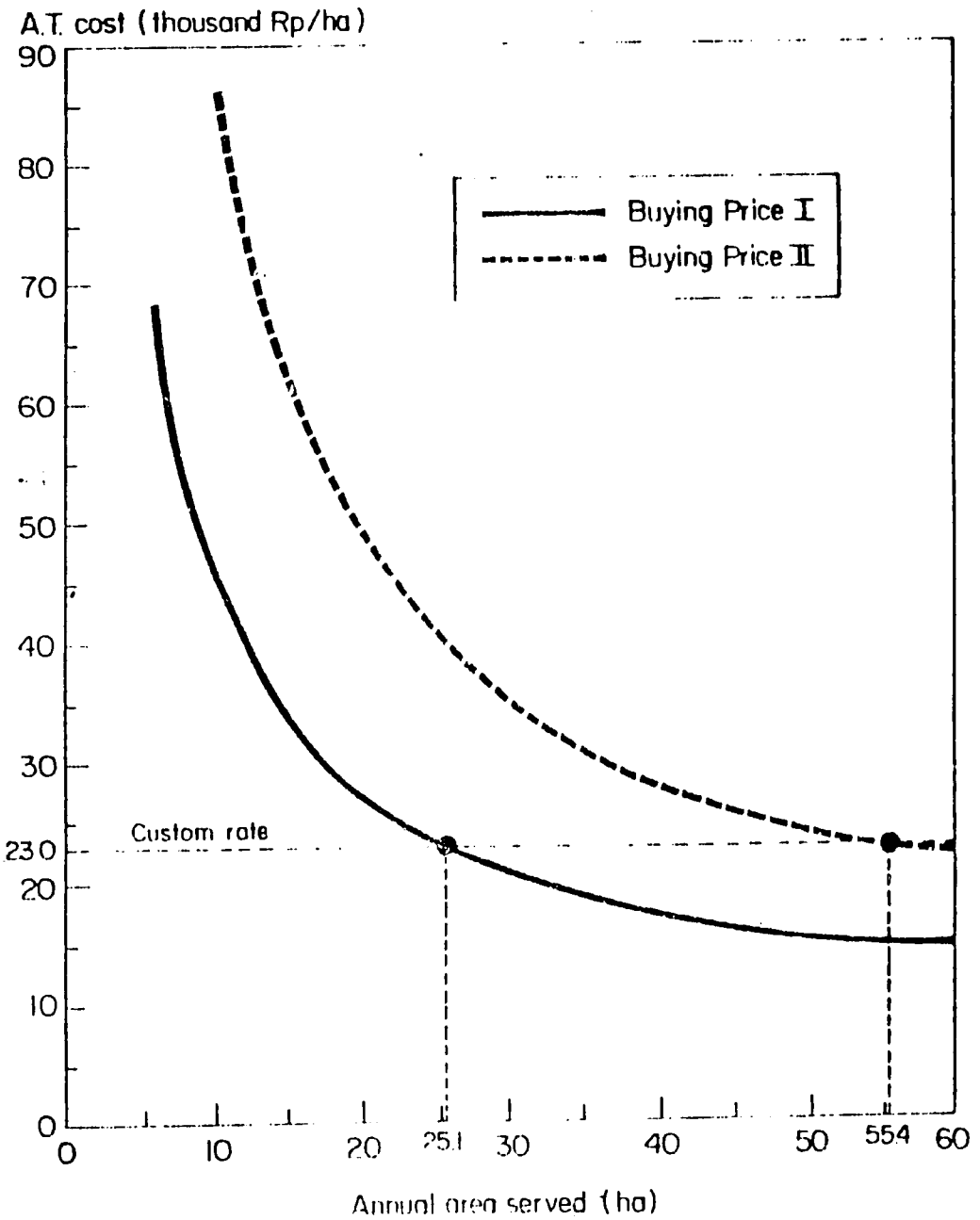

Figure 3. Cost curve-area served relationship for a diesel tractor.