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THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

Working Paper No. 8

A Methodology for Identifying Lowland Rice Farms

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The Consequences of Small Rice Farm Mechanization Project is a cross country study of the impact of engineering technologies on agricultural output, employment and income distribution. The project, a centrally funded activity of the United States Agency for International Development, has two major components. The first is a series of case studies addressing specific topics relating to the application of mechanization. The majority of the case studies are funded through awards from the Agricultural Development Council to graduate and post-graduate research personnel in the Asian region. A second component is a three country comparative study being administered by the International Rice Research Institute in cooperation with agencies in Thailand, Indonesia and the Philippines. This portion of the project consists of a series of stratified cross sectional surveys and daily recordkeeping activities at sites in the above countries. Details of the field design and research methodology are contained in the operations manuals noted on the last page of this report.

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A METHODOLOGY FOR IDENTIFYING LOWLAND RICE AREAS THAT WOULD BENEFIT FROM THE MECHANIZATION OF LAND PREPARATION

R. H. Bernsten and R. C. Sinaga

Indonesia with its population of 140 million persons is the fifth largest country in the world and is growing at a rate of slightly over 2%/year. Since 67% of this population lives on Java, Madura and Bali with only 6% of the land area, the population density on the Inner Islands is approximately 670 persons/km^2. In contrast, the Outer Island are sparsely settled at a density of only 27 persons/km^2.

Recently, several events have caused increased concern about the future of the rice economy. First, while rice output grew at 4.0%/year during the first development plan, Pelita I (1968-73), the rate of increase fell to 2.3%/year during Pelita II (1974-78). Second, in 1976-77 brown planthopper damage was extensive, seriously reducing rice yields and output. Third, although a large investment has been made in increasing the irrigation capacity on Java, the expected yield increases have been slow in materializing. Fourth, the rate of repayment of Bimas supervised credit loans has fallen, possibly because of insect related crop failures. Fifth, in 1977-78 rice production shortfalls made it necessary for the Government to import 2.3 million metric tons of rice, equal to about one-third the amount that entered the world market during the period. Finally, there is concern that the Governments' attempt to reduce insect damage

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by implementing an integrated pest control strategy that includes synchronized planting of large blocks of lowland rice will be constrained as labor bottlenecks appear during land preparation.

Taken together, these factors have created an intense interest in raising rice yields through the development and extension of improved rice technology. In addition, policy makers have shown increased interest in the mechanization of land preparation in order to expand the area under food crop production and to increase cropping intensity.

THE POLITICAL ECONOMY OF MECHANIZATION

Since the question of mechanization is a critical issue with far reaching social and economic implications, a large number of parties can be expected to participate in the debate. First, some individuals see mechanization as a means for breaking the labor bottleneck which they believe prevents farmers from achieving a higher cropping intensity. Second, businessmen holding franchises for selling power tillers and tractors are interested in expanding their market area. Third, rural enterpreneurs are interested in acquiring a tractor to provide contract plowing services at a profit. Fourth, farmers who operate several hectares and find it difficult to manage large labor crews needed to prepare their holdings, perceive mechanization as a strategy for achieving timely land preparation. Fifth, even small land owners support mechanization when contract plowing services reduce the cost of land preparation. Finally, mechanization is often associated with modernization and may be supported by some individuals as a means of transforming traditional agriculture.

POTENTIAL IMPACT OF MECHANIZATION

The mechanization of land preparation can have several potential consequences that must be taken into consideration when discussing mechanization policy. First, preparing land by hand is extremely backbreaking work. Hence, one benefit of mechanization is to reduce the drudgery of preparing the soil. While this effect cannot be easily given a price, we must not fail to keep in mind the importance of this benefit.

Second, mechanical land preparation may increase yields where the traditional tillage techniques are inadequate. For example, where labor is in short supply mechanical tillage may produce a finer tilth and as a consequence, a better seedbed than human tillage. As a result, water percolation may be reduced and yields increased. Also, in areas where weed are a yield constraint, mechanical tillage can provide improved weed control and boost yields. Finally, under conditions where mechanical power permits the farmer to plant his crop earlier, yield may be increased. This timeliness effect can manifest itself in several ways. For example, earlier planted crops may capture more solar radiation and escape late season climatic threats such as typhoons, drought or floods.

Third, where there is a shortage of human labor relative to the land resource, mechanical power can increase the productivity of labor and thereby permit an expansion in the total physical areas under cultivation. This effect is most applicable to the sparsely populated Outer Islands.

Fourth, the mechanization of land preparation may also permit an increase in the rice cropping intensity. With the introduction of short duration rice varieties, it is biologically possible to grow 3 crops per year. Mechanization can enable farmers to increase their cropping inten-

sity by allowing them to prepare their land earlier. This may be realized by either breaking an existing labor bottleneck or by providing the power necessary to prepare land that could otherwise not be cultivated until after the early season rains had soften the soil. In addition, mechanical power may reduce the turnaround time between the first and second rice crop where a labor bottleneck presently extends the land preparation time over several weeks.

Fifth, mechanical land preparation is often cheaper than human or animal tillage. Where this is the case, the net returns to the owner of farm operator will increase as a consequence of adapting the technology.

Sixth, the most obvious negative impact of mechanization is labor displacement. Record keeping data suggest that in Java manual land preparation requires approximately 80MD/ha, compared to 3MD/ha with a 7 hp power tiller 2MD/ha using a 15 hp mini-tractor. Hence, we see that one tiller or mini-tractor can do the work of 27 or 40 laborers/ha, respectively. As long as off-farm and non-farm employment opportunities are expanding rapidly enough to absorb these individuals, there is little need for concern. Yet, when these sectors are stagnant or capable of absorbing only a portion of the displaced labor, the benefits of mechanization must be carefully weighed against the social consequences.

Seventh, in most instance mechanization received explicit subsidies from Government in terms of low interest loans to the purchaser. In addition, implicit subsidies may exist such as reduced import tariffs and undervalued foreign exchange rates. To the extent that mechanization is dependent on such policies, Government supports the transfer of income from owners of labor services to owners of capital.

Finally, the financial feasibility of mechanization is dependent on a certain minimum number of hectares being prepared each season. Where conditions exist which prevent the achievement of this goal, the economic rational for Government supporting mechanization breaks down completely.

REQUIREMENTS OF RELEVANT POLICY ANALYSIS

To thoroughly investigate all of the potential impacts of mechanization, a complex study must be conducted over two to three years at several locations. While IRRI's Cooperative "Consequences of Mechanization" project meets some of these requirements, it has limitation. Several years will be required to analyze the data. In addition, it may be difficult to apply the results to other sites with different resource endowments. Consequently, while complex studies will contribute to our understanding of the impact of mechanization, they will not provide policy makers with information they need to make immediate decisions about mechanization policy.

It is imperative that researchers interested in serving the needs of policymakers develop a research strategy which is straightforward and easy to understand, capable of providing results which are clear and easy to apply, and can rapidly provide policy guidelines. Finally, the research required to generate these guidelines must be inexpensive to carry out so that the research and resultant policy can be targeted at the village or sub-district levels in order to take into consideration variability in local conditions.

ESTIMATING THE DEMAND FOR MECHANIZATION USING A LABOR BALANCE APPROACH

The monthly demand for lowland rice land preparation labor may be approximated as the area that was planted the previous year during that month. The area that can be prepared by the available supply of labor, carabao, power tillers and mini-tractors may be approximated by:

(1) $S_{ha} = M_{ha} + A_{ha} + P_{ha}MT_{ha}$

(2) $M_{ha} = \dfrac{Ma[(MpAgWf)] - [2(AaApAw + PaPpPw + MTaMTpMTw)]}{MD}$

(3) $A_{ha} = \dfrac{Aa(ApAw)}{AD}$

(4) $P_{ha} = \dfrac{Pa(PpPw)}{PD}$

(5) $MT_{ha} = \dfrac{MTaMTpMTw}{MTD}$

where:

S_{ha} = estimated hectares/months that is prepared by existing supply of human labor, animals, and machinery

M_{ha} = estimated hectares/month prepared by existing human labor

A_{ha} = estimated hectares/month prepared by existing animal labor

P_{ha} = estimated hectares/month prepared by existing power tillers

MT_{ha} = estimated hectares/month prepared by existing mini-tractors

Ma = days/month a man normally works

Aa = days/month a draft animal is normally used

Pa = days/month a power tiller normally used

MTa = days/month a mini-tractor is normally used

Mp = male population

Ap = draft animal population

Pp = power tiller population

MTp = mini-tractor population

Ag = percent of male population in agriculture

Wf = percent of males in labor force (15-54 years old)

Aw = percent of draft animal of working age

Pw = percent of power tiller operating

MTw = percent of mini-tractors operating

MD = mandays required to cultivate 1 hectare

AD = animal days required to cultivate 1 hectare

PD = power tiller days required to cultivate 1 hectare

MTD = mini-tractor days required to cultivate 1 hectare

Let us assume the set of data as shown in Table 1 was collected from a village with 5,000 ha. to be transplanted in May.

Substituting into the formulas we obtain:

(3) $$A_{ha} = \frac{20[[(5,000)\ (0.75)]]}{20} = 3,750$$

(4) $$P_{ha} = \frac{20[[(50)\ (0.9)]]}{3} = 300$$

Table 1. Village characteristics and coefficient used in labor balance model.

Population (number)		
men	(Mp)	17,000
animal	(Ap)	5,000
power tiller	(Pp)	50
mini-tractor	(MTp)	20
Work capacity (days)		
men	(Ma)	24
animal	(Aa)	20
power tiller	(Pa)	20
mini-tractor	(MTa)	20
Availability convertion factors (percent)		
male population in agriculture	(Ag)	80
male population in labor force	(Wf)	70
draft animals of working age	(Wa)	75
power tillers operating	(Pw)	90
mini-tractors operating	(MTw)	90
Technical coefficients for land preparation (days/ha)		
human labor	(MD)	80
draft animal	(AD)	20
power tiller	(PD)	3
mini-tractor	(MTD)	2

$$(5) \quad MT_{ha} = \frac{20[[(20)(0.9)]]}{2} = 180$$

$$(2) \quad M_{ha} = \frac{24[[(17,000)(0.8)(0.7)] - 2\{(20)(5,000)(0.75) + (20)(50)(0.9) + (20)(20)(0.9)]]}{80} \doteq 949.5$$

$$(1) \quad S_{ha} = 3,750 + 300 + 180 + 949.5$$

$$= 5,179.5$$

Hence, there is enough capacity existing in the village to prepare approximately 5,200 hectares during the month.

This figure may be compared to the area actually planted each month. If the supply (S_{ha}) greatly exceeds area planted during the month, we can assume that power is probably not a constraint to land preparation. If S_{ha} approaches or exceeds the area planted, the possibility of a power constraint increases.

This methodology suffers from at least three weaknesses. First, we know that labor is mobile with residents of a village migrating to other areas for seasonal employment and vice versa. Yet, by assuming mobility of labor, this model can be expanded to include several villages, irrigation blocks, sub-districts, or districts and the effect of this expansion on the labor supply-demand balance can be observed in each level of aggregation. Second, the area planted in a given month may have been prepared over the previous several months, but not transplanted at that time. Farmers generally plant during a common short period to avoid excessive rat damage which would occur if the field was planted out of phase with others in the community. Hence, while this methodology is indicative, it will not provide a conclusive answer to whether or not a power constraint exists which delays land preparation. Third, the methodology does not

provide any insights into the related potential benefits from mechanization such as its impact on yield, area expansion, reducing turn-around time and reducing costs of land preparation.

ESTIMATING THE NEED FOR MECHANIZATION USING INDIRECT INDICATORS

It may be possible to evaluate the probable impact of the mechanization of land preparation by using a set of indirect or proxy variables. Of course, the validity of this approach rests on our ability to identifying a relevant set of proxies that can be easily estimated for each village. Table 2 presents a hypothesized set of variables selected to measure the impact of mechanization on yield, area, cropping intensification, net returns, and labor displacement. A detailed description of each variable is presented in Appendix I.

This data can be used as described below. First, once collected for a set of villages, the data may be entered into a matrix. For each village, the value for each variable can be compared to the mean, maximum, and minimum values for the data set. Examination of the values for each variable will identify those for which the variability is greatest and as a consequences, may have the greatest predictive power. Also, it is probable that some of the variables will be highly related. By using correlation analysis, it would be possible to identify a subset of these variables that are independent. In future data collection efforts, this reduced set of data could be collected, thereby reducing the time required to assemble and evaluate the data.

Second, once the set of "best" variables is identified an indicator index could be developed by ranking each village in terms of each of the

Table 2. Indicators of the impact of mechanizing land preparation.

Yield	
Weed control (WC)	$\frac{\text{normal yield}}{\text{yield with good weed control}}$
Timeliness (TM)	$\frac{\text{yield of early harvest}}{\text{yield of mid-season harvest}}$
Area (A)	$\frac{\text{Total cultivatable area minus Total planted area}}{\text{farmer population}}$
Cropping intensity	
Cropping index (CX)	$\frac{\text{Total cropped lowland}}{\text{Total lowland area}}$
Rate of land preparation work (R)	$\frac{\text{Area transplanted, 1st and 2nd month}}{\text{total WS area}}$
Trend labor shortage (TLS)	$\frac{\text{Real daily wage rate for LP, WS 79}}{\text{Real daily wage rate for LP, WS 74}}$
Intra-seasonal labor shortage (SLS)	$\frac{\text{Real daily wage rate for LP}}{\text{Real daily male wage rate for weeding}}$
General labor shortage (GLS)	$\frac{\text{MD of hired labor used for LP, WS}}{\text{MD of total labor used for LP, WS}}$
Inter-seasonal labor shortage (ILS)	$\frac{\text{Daily hired wage rate for LP, DS}}{\text{Daily hired wage rate for LP, WS}}$
Increase net returns (NET)	$\frac{\text{LP cost/ha with man}}{\text{LP cost/ha with mechanical power}}$
Labor displacement	
Off-farm jobs (OFF)	Off-farm job index
Non-farm jobs (NON)	Non-farm job index
Landless labor (LL)	$\frac{\text{Total land owners}}{\text{Total farmers}}$

LP = land preparation
WS = wet season
DS = dry season

variables. For example, if there were 30 villages surveyed, the one with the greatest percentage increase in real land preparation wages (indicator TLS) would be assigned a score of one and the village with the smallest change the value 30. After all villages are ranked in this manner, the scores for all variables for each village, can then be summed (Table 3). The village with the lowest score would be the one with the greatest potential need for the mechanization of land preparation. Alternatively, the researcher may choose to assign weights to the various indicator variables to reflect preferences regarding the trade off, for example, between increasing yield through better weed control at the cost of displacing labor.

Third, having identified villages where mechanization seems to be needed most, validation surveys could be undertaken in these villages to determine the social, economic, and institutional factors responsible for each villages's low score on the indicator index. For example, in one village indicator R may suggest that land preparation is extended over several weeks, but from the survey we learn that this is because irrigation water is not available. In another village, indicator CX may show that the cropping index is very low, but from the survey we learn that 50 percent of the farmers rotate lowland rice with sugarcane. In a third village indicator variable A tells us that the uncultivated area/farmer is large, but the survey shows that this rainfed land is owned by a few families who use it to graze cattle. Consequently, the on-site validation survey is necessary to identify the primary constraints and permit use to differentiate between villages with a real need for mechanization from those with other problems. In addition, such studies would make it possible to recommend

Table 3. Index of indicator variable scores for five villages, an illustration example.[a]

Indicator variable	Village				
	A	B	C	D	E
WC	1	2	3	4	5
TM	2	3	4	1	5
A	1	5	2	4	3
CX	3	2	4	5	1
R	2	1	4	5	3
TLS	3	2	1	4	5
SLS	4	2	1	3	5
GLS	1	4	3	5	2
ILS	3	2	1	4	5
NET	2	1	4	3	5
OFF	1	3	5	4	2
NON	4	2	3	5	1
LL	3	1	2	5	4
Σ	30	30	37	52	46

[a]The values assigned to each variable for each village are to illustrate the concept. No attempt is made to represent the probable relationship between any variables for a given village. In this example villages A and B show greatest potential for mechanization.

alternative technological solutions for breaking observed labor bottleneck. For example, where transplanting is extended over a long period of time it may be possible to introduce dry seeded rice and thereby reduce the demand for labor during the peak land preparation period.

CONCLUSION

Indonesian policy makers are concerned about the food crop situation and are considering the mechanization of land preparation as a possible means to increase the productivity of agriculture. Consequently, there is a need to develop a methodology for identifying the areas where mechanization will have the greatest positive and least negative impact.

The "labor balance" and "indirect indicator" methodologies represent first approximation approach for identifying labor bottleneck. Once areas have been identified where labor shortages appear to act as constraints, on-site studies should be conducted to identify the causal factors. In general, efforts should be made to first break identified labor bottlenecks through strategies such as the introduction of non-mechanized technologies such as new cultural practices and varieties, by increasing the mobility of labor from surplus to deficit labor areas, and by modifying the irrigation schedule. Only when it has been determined that these approaches cannot be successfully employed to break the labor bottleneck, should mechanization be relied upon to accomplish this goal.

Appendix I. Detailed description of mechanization impact indicators

1. Yield effect of better weed control (WC)

Description : Farmers' estimate of "normal" yield divided by farmers' estimate of yield with "good" weed control. The resulting figure would estimate the percent yield increase to be gained by improved weed control.

Data source : Interview a random sample of ten farmers/village

Rational : In locations where labor is adequate or in excess of demand, we would expect labor input for weeding to be high and with little or no output increase to be obtained from better weed control. Where labor is in short supply, the reverse would be true. While mechanized land preparation in labor surplus areas may have a potential for reducing weed costs, this effect is not considered in our analysis.

2. Yield effect of timeliness (TM)

Description : The average yield of fields harvested during the first decile of the harvest period divided by the yield of the fields harvested during the middle decile. The resulting figure would estimate the percent yield increase to be gained by early harvesting.

Data source : It may be possible to obtain this data from the village office. Alternatively, Bureau of Central Statistics crop cut yield data may be evaluated to determine the relationship between time of harvest and yield.

Rational : Since harvest date is highly correlated with planting date and easier to obtain, we use it as a proxy variable.

In a given area, earlier harvesting may permit a farmer's crop to receive more solar radiation or avoid drought and floods. If this hypothesis is correct, by planting earlier farmer would be able to capture this benefit.

3. Area effect (A

Description: Total area that is classified as "cultivatable for lowland rice" minus total planted wet season area divided by the population of farmers. The resulting figure would estimate the usable but presently uncultivated lowland area/farmer.

Data source: Village office and local agricultural extension office.

Rational: In densely populated areas we would expect all of the land that could be cultivated for lowland rice to be in production. On the other hand, in sparsely populated areas, there may be fallow land that could be utilized.

4. Measure of current cropping intensity (CX)

Description : Total area planted to lowland rice during the year divided by total physical area planted to lowland rice in the wet season. This calculation generates an index.

Data source : Village office

Rational : Areas with a low lowland rice cropping index has less potential for intensification than areas with a high index. While it may not be possible to increase the cropping index in the areas with a low index, this data will permit the researcher to screen out villages that have little potential.

5. Slow transplanting (R)

Description : Area planted during the first four weeks of the wet season divided by the total lowland area planted. This calculation will generate a figure showing percent of area transplanted at the beginning of the wet season.

Data source : Village office

Rational : Where labor is in surplus, we would expect the lowland area to be prepared and planted relatively rapidly at the beginning of the wet season. When labor is scarse, these activities may be extended over a longer period.

6. Trend labor shortage (TLS)

Description : Real wage rate for land preparation in current year divided by the real wage rate five years ago. Real wage rates may be approximated by dividing the respective nominal wages by the price of rice in that year. These computations will estimate the percent change in real wages.

Data source : Wages and price can be estimated by surveying a random sample of ten farmers/village. Alternatively, the price of rice may be obtained from the Central Bureau of Statistics.

Rational : If land preparation labor has become increasingly scarce over the past five years, the real cost of labor should have also increased. If labor is in excess of demand, real wages will have declined.

7. Intra-seasonal labor shortages (SLS)

Description : Wage rate/day for land preparation divided by the wage rate/day for male weeders. These computations estimate percent difference in intra-seasonal wages.

Date source : Interview a random sample of ten farmers/village

Rational : The demand for labor will be greatest during land preparation since timeliness is critical. On the other hand, because weeding may be scheduled over a longer period of time without significant yield loss, this wage may represent the equilibrium rate. Hence, the larger the percentage difference, the greater the demand for labor during land preparation, relative to the equilibrium wage rate.

8. General labor shortage (GLS)

Description : Total amount of hired labor used for land preparation divided by the total amount of land preparation labor

used. This calculation gives percent of land preparation labor hired.

Data source : Interview a random sample of ten farmers/village

Rational : Generally, farmers hire more labor in areas where there is surplus labor. This may be because in such locations, wage rates are lower than where labor is scarce.

9. Inter-seasonal labor shortages (ILS)

Description : Hired wage rate/day for land preparation for the early dry season, divided by the hired wage rate/day for land preparation in the wet season. This calculation gives the relative cost/day for dry relative to wet season land preparation.

Data source : Interview a random sample of ten farmers/village

Rational : If labor is scarce in the early dry season because individuals can find alternative high paying employment harvesting the late maturing wet season crop, the early dry season wage rate should be higher than the wet season rate.

10. Increase net returns (NET)

Description : Cost/ha of manual land preparation divided by cost of machine land preparation. This calculation gives the relative cost of the two alternative technologies.

Data source : Interview a random sample of ten farmers/village. In areas where plowing services are not provided

machines, data from nearby villages may be used to estimate the cost if machinery were introduced.

Rational : Presently, in areas where power tillers and mini-tractors operate, the cost of mechanical land preparation is less than manual. If labor is scarce, we would expect the reverse to be true.

11. Off-farm employment (OFF)

Description : Laborers' evaluation of the availability of off-farm employment during the past wet season, relative to five years ago. Responses should be scored as 1 = much less, 2 = less, 3 = same, 4 = more, 5 = much more. This produces an index of changes in off-farm employment.

Data source : Interview a random sample of ten landless laborers/village

Rational : If laborers find it increasingly difficult to find off-farm employment, this indicates a surplus of labor relative to demand. If jobs are easier to find, the demand for labor has probably increased and a shortage may exist.

12. Non-farm employment (NON)

Description : Laborers' evaluation of the availability of non-farm employment during the past wet season, relative to five years ago. Responses should be scored as 1 = much less, 2 = less, 3 = same, 4 = more, 5 = much more. This produces an index of changes in

non-farm employment.

Data source : Interview a random sample of ten landless laborers/village

Rational : If laborers find it increasingly difficult to find non-farm employment, this indicates a surplus of labor relative to demand. If jobs are easier to find, a labor shortage may exist.

13. Landless laborer (LL)

Description : Total number of landowners divided by total number of farmers. This calculation approximates the percent of farmers owning land.

Data source : Village records

Rational : In villages where a few farmers own land, there will be a greater percentage of landless labor. In these villages we would expect to find a relative surplus of labor since villages with high land holding concentrations tend to be densely populated.

CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

Operations Manual

1. Moran, P. and D. Unson. Farm Survey and Recordkeeping Procedures for Consequences of Small Rice Farm Mechanization Project. Revised May 1980.

2. Wicks, J.A. Procedures for Constructing Two-Way Tables for Consequences of Small Rice Farm Mechanization Project. January 1980.

3. Wicks, J.A. Specification of Variables to be Included in Data Files for Consequences of Small Rice Farm Mechanization Project. October 1980.

Working Papers

1. Juarez, F. and B. Duff. The Economic and Institutional Impact of Mechanical Threshing in Iloilo and Laguna. October 1979.

2. Pathnopas, R. The Economics of Rice Threshing Machines in Thailand: A Case Study of Chachoengsao and Supanburi Provinces. October 1979.

3. Gardezi, J., A. Rauf, M. Munir, K. Altaf, Q. Mohd-ud-Din, and B. Lockwood. A Study of Mechanical and Traditional Wheat Threshing in Multan District, Punjab, Pakistan: Some Preliminary Results. October 1979.

4. Habito, C. and B. Duff. A Simulation Model to Evaluate Mechanization of Rice Postharvest Operations in the Philippines. October 1979.

5. Chapman, J. The Potential of Mechanization for Crop Intensification in a Rainfed Area - Iloilo, Philippines. October 1979.

6. Thapa, G. The Economics of Tractor Ownership and Use in the Nepal, Terai. October, 1979.

7. Jongsuwat, N. Productivity Growth and Farm Machinery Adoption in Thai Agriculture. April 1980.

8. Bernsten, R.H. and R. Sinaga. A Methodology for Identifying Lowland Rice Farms that would Benefit from the Mechanization of Land Preparation. October 1979.

9. Bernsten, R.H. and A. Rochim. Labor Shortage as a Constraint to Increasing Cropping Intensity. Revised March 1980.

10. Ayob, A.M. The Economics and Adoption of the Combine Harvester in the Muda Region of Malaysia. October 1979.

11. Lubis, R. Impact of Cropping Pattern Technology on Income, Employment, and Production: A Case Study on Expanded Crop Production in Lampung, October, 1979.

12. Wicks, J.A. Modelling the Consequences of Future Mechanization: An Outline of Possible Procedures. October 1979.

13. Khoju, M. R. and J. A. Wicks. Economics of Pump-Irrigation in Eastern Nepal. August 1980.