PN-AAN-541
ISN 31709

THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

Working Paper No. 43

THE IMPACT OF MECHANIZATION ON PRODUCTION AND EMPLOYMENT IN RICE AREAS OF WEST JAVA

By

Al-Sri Bagyo
Central Research Institute of Agriculture

and

John Lingard
The International Rice Research Institute

1981

The Consequences of Small Rice Farm Mechanization Project is supported by the United States Agency for International Development under Contract tac-1466 and Grant No. 931-1026.01 and is being implemented by the International Rice Research Institute and the Agricultural Development Council, Inc.

ABSTRACT

The effects of mechanization on production and rural employment in the rice areas of West Java were analysed using three different methods. A t test indicated that fertilizer use was higher on mechanized farms. In contrast, mechanized farms used less pesticides than non-mechanized farms. Although labor use per hectare per season was lower on mechanized farms, the total annual labor use per farm was higher due to big area differences. Mechanized farms had a lower cropping intensity. Decomposition analysis was used to investigate the impact of mechanization on production and total labor use. Results showed the most important explanator to be area, while yield and cropping intensity had only minor effects. The area effect also gave the highest percentage contribution to the total labor use. Regression analysis was used to further determine whether yield differences were mainly due to mechanization or to other factors. Results again showed farm size and fertilizer use were the main explanators, mechanization dummies were small and insignificant and pesticide use was both significant and negative.

INTRODUCTION

In West Java, rice mechanization enables double cropping to take place. The introduction of double cropping was made possible both by the construction of Jatiluhur dam and the introduction of early maturing rice varieties and this has tended to create a much greater impetus for farm mechanization. Additional land could be cultivated and cropping intensity could be increased due to better irrigation and therefore, more labor was needed to counterbalance the increase in rice area.

There is an insufficient supply of local labor during peak seasons of labor demand and the shortage becomes critical when there is no inflow of migrants or outside supplementary labor to help in maintaining the farm operations within irrigation schedule time periods. Some authors and public figures have welcomed this development. Referring to a shortage of agricultural labor in rural areas, some have suggested that large amounts of rice fields have in the past been left uncultivated or improperly cultivated because of the labor shortage, and many advocated the rapid introduction of tractors particularly in Karawang, Subang and Indramayu regions where a labor shortage exists for land preparation before planting the dry season paddy crop.

Imported hand-tractors and smaller numbers of four wheeled mini-tractors have been rapidly adopted in sawah (lowland ricefields) cultivation since 1975 in parts of rural Java and Bali particularly in the north coastal plain of Java, although no statistics are available on the number of tractors presently in use.

OBJECTIVES

The study was conducted with the following objectives:

1. To compare input use, labor use, cropping intensity, farm size and output between mechanized and non-mechanized farms.

2. To decompose the effects of mechanization on total output and total labor use into its component elements such as cropping intensity, area and yield or labor use per hectare.

3. To find whether the difference of yield is mainly due to mechanization or differences in using other inputs such as fertilizer and pesticide.

Part of the survey for the "Consequences of Small Rice Farm Mechanization Project in Asia" conducted by the International Rice Research Institute in Indonesia, was taken as the source of data in this study. In Indonesia, the survey was conducted in two provinces, South Sulawesi and West Java. The West Java data of Wet season 1979/1980, Dry Season I 1980 and Dry Season II 1980 were used in this study.

METHOD OF DATA COLLECTION

Two sample districts in West Java with the most tractor users were selected. Based on this criteria, Subang and Indramayu were selected as sample districts. From each sample district, four villages with the highest population of farmers using tractors were identified and taken as sample villages. Before selecting the sample farmers, a block census was conducted in all sample villages. Census respondents were grouped based on land cultivation tools used in wet seasons 1979/1980. Six groups taken for sample stratification were tractor owner, tractor hirer, animal user, manual labor user, animal and manual labor user and landless farmer. A total of sixty sample farmers were selected from each group in each sample village based on the proportion of each group in each village in the census so that there were 360 sample farmers in the study. Since some of the samples gave incomplete information for the purpose of the study, only 282 were eventually used. The samples were grouped into six categories based on the tools used for land preparation as shown in Table 1. If a farmer for plowing and harrowing in two seasons (four passes land preparation) only used a tractor, he was considered as a pure mechanized farmer (T_1). If he used labor only, he was a pure manual farmer (M_1). An animal-manual farmer (A_1) used half animal and half manual. If three quarters of the land preparation was done by tractor, he was a mainly-mechanized farmer (T_2). If three quarters of land preparation was done by labor, he was a mainly-manual farmer (M_2). For T_3, the farmer used either tractor, animal or labor in several combinations so that he could not be classified as mechanized or non-mechanized farmer.

THE STUDY AREA

The surveys were conducted in the districts of Subang and Indramayu, in the province of West Java. Four sample villages with a high degree of mechanization were selected from each district. In Subang, the sample villages were Bojongsengah, Pamanukan, Mariuk and Tambakdahan, while in Indramayu they were Sukadana, Gabuskulon, Anjatan and Sukra. The number of sample farmers included for each village is shown in Table 2.

METHODOLOGY

To test whether the input use, labor use, cropping intensity, farm size and output between mechanized and non-mechanized farms were significantly different, a t-test was used. Arithmetic means of each variable for both mechanized and non-mechanized farms were computed separately. The observed differences in the mean level between mechanized and non-mechanized condition were tested by a t-statistic.

To decompose the effects of mechanization on total output and total labor use into its component elements, Decomposition analysis was used as a combination of the models formulated by Binswanger (1970), by Krishna (1976), and subsequently developed by Tan (1981) where:

$$\Delta Q = \Sigma Ci^{\circ}.A^{\circ}\Delta Yi.Pi \quad - \quad \text{yield effect}$$

$$+ \Sigma Ci^{\circ}.Yi^{\circ}\Delta A.Pi \quad - \quad \text{area effect}$$

$$+ \Sigma A^{\circ}.Yi^{\circ}\Delta Ci.Pi \quad - \quad \text{cropping intensity effect}$$

$$+ \Sigma Ci^{\circ}\Delta Yi\Delta A.Pi \quad -$$

$$+ \Sigma A^{\circ}.\Delta Ci\Delta Yi.Pi \quad - \quad \text{first order interaction effect}$$

$$+ \Sigma Yi.\Delta Ci.\Delta A.Pi$$

$$\Sigma\Delta Ci.\Delta Yi\Delta A.PI \quad - \quad \text{second order interaction term}$$

and

ΔQ = output difference between mechanized and non-mechanized farms

A° = farm size or area of non-mechanized farms

ΔA = area difference

Ci° = cropping intensity of ith crop of non-mechanized farms; when i = 1 crop is rice, i = 2 crop is beans

ΔCi = cropping intensity difference

Yi° = yield of non-mechanized farms

ΔYi = yield difference

Pi = price of ith crop

The approach used in decomposing labor use differences due to mechanization was essentially similar to that used in decomposing output differences. Production function analysis was used to support the decomposition analysis in analyzing the impact of mechanization on production so that it could be determined whether the difference of yield was mainly due to mechanization or the difference in using other inputs such as fertilizer and insecticide.

RESULTS

Tables 3 and 4 show results of the test for differences of input utilization between mechanized and non-mechanized farms using the t-test. In general, mechanized farms used more fertilizer per hectare than non-mechanized farms and when the mechanized farm groups used less fertilizer than non-mechanized farm groups, the difference was not significant. Since Table 5 and 6 also show that mechanized farms size was about three times higher than non-mechanized farm size, it can be tentatively suggested that farmers using tractors were wealthier and were more able to afford fertilizer than farmers not using tractors.

Mechanized farms used less pesticide per hectare than non-mechanized farms. This result was contrary to some previous studies which reported that mechanization increased input utilization including crop protection inputs such as pesticide. Farmers using tractors were expected to have a better education and know when to use pesticide. During the study period there was no serious pest damage consequently they did not use too much pesticide. But the farmers not using tractors are small farmers who bear more risk since their family life depends solely on their small farms and they often use pesticide as a precautionary measure. So even if there was no serious pest damage, they still used more pesticide than farmers using tractors. Even when some mechanized farmer used more pesticide than non-mechanized farmer groups the difference was not significant.

Labor use per hectare per season was lower on mechanized than on non-mechanized farms. This result was consistent with the results of several previous studies which found that mechanization replaces animal and labor power. Since the assumed reason large farms used tractors is a labor shortage during the peak season of labor demand, it is not unexpected that mechanized farms used less labor than non-mechanized farms.

For labor use per farm per year, mechanized farms used more labor than non-mechanized farms. Even if labor use per hectare per season was lower on mechanized than on non-mechanized farms, the size of mechanized farms was about three times larger (Table 5 and 6) and the impact of area increase exceeded the impact of labor decrease.

Tables 5 and 6 show the test for differences of farm size, cropping intensity and production between mechanized and non-mechanized farms. Mechanized farm size was significantly larger than non-mechanized farm size. In the study area, the use of hand tractor by large farms was a response to the problem of getting labor in the peak season of labor demand while small farms do not normally have such problems. Consequently mechanized farms had a larger size than non-mechanized farms. The fact that mechanized farms had a significantly lower cropping intensity than non-mechanized farms was contrary to most previous studies. Only large farmers used tractors and they did not attempt to raise crops in the third season since this is too risky due to water shortage.

The yield per hectare both per season and per year was higher on mechanized than on non-mechanized farms. Since input data showed that mechanized farms used higher fertilizer than non-mechanized farms, it should be determined whether the yield increase was due to mechanization or fertilizer.

Production per farm per year was higher on mechanized than on non-mechanized farms. This result was expected since mechanized farms had higher yield and larger farm size.

Decompostion Analysis

The results of decomposition analyses are presented in Tables 7 and 8. Table 7 shows that the component element which contributed the largest percentage of the output difference between mechanized and non-mechanized farms was the area effect. This varied between 87 and 123 percent. Taking comparison between T_1 (pure mechanized farms) and M_1 (pure animal farms), the area effect was 97 percent. This means that if these two types of farms only had an area difference and other component elements were the same, the output difference would be 97 percent of the absolute change. The same case occurs with yield and cropping intensity. If yield was the only difference, the two type of farms would have an output difference of 7 percent of the absolute change. If the only difference between the two typesof farms was cropping intensity, there would be output difference of 3 percent of the absolute change. Negative sign means mechanized farms would have lower output than non-mechanized farms.

For the first order interaction effects, the interaction effect of yield and area was 13 percent out of absolute change. It means that yield and area differences of the two farm types simultaneously had an impact on the output difference of 13 percent, while area and cropping intensity had an interaction effect of 9 percent out of the absolute change. The interaction effect of yield and cropping intensity was very small.

In the case of second order interaction effects, the interaction effect of yield, area and cropping intensity was bery small or 1 percent.

Table 8 also shows that the component element which contributed the largest percentage to the total labor use difference between mechanized and unmechanized farms was the area effect which varied between 152 to 207 percent out of the absolute total labor use. Labor use per hectare gave a negative effect and varied between 14 to 23 percent. Cropping intensity also gave a negative effect and varied between 3 to 16 percent. The interaction effect of labor use per hectare and area was negative and varied between 25 to 67 percent while area and cropping intensity gave a negative interaction effect of 7 to 20 percent. Other interaction effects were very small. All decomposition analyses showed that the most important factor explaining the total output and total labor differences between mechanized and unmechanized farms was area.

Production function analysis was also used to explain whether difference of yield was mainly due to mechanization or other factors like fertilizer and pesticide use. In Table 9, a Cobb Douglas production function is presented with yield as the dependent variable. Some 87% of the variation in yield is explained by the function with farm size, nitrogen use and insecticide use being statistically significant at the 1% level, trisuperphosphate at the 5% level. Farm size and nitrogen use are the major explanators, the coefficients have the expected order of magnitude but the negative sign for insecticides is surprising since generally in the north coastal rice areas of West Java including the data site a main constraint to increasing yield, is pest damage. The result is however consistent with earlier researches that during the survey there was no serious pest damage and consequently insecticide use had no effect on yields.

The coefficients sum of 1.05 indicates constant returns to scale across the sample and the mechanization dummies for T_1 (pure mechanized farms) and T_2 (mainly mechanized farms) are both small and insignificant. The negative sign for the T_2 coefficient is however somewhat surprising. A further specification of the functional form seeking to explain per hectare yields in terms of per hectare input use produced no improvement on the results presented in table 9.

SUMMARY

Three different methods have been used to analyze the effects of mechanization on production and labor use in rice areas of West Java. Differences in input use between mechanized and non-mechanized farms have been systematically explored in 3 ways and although we may be accused of'using a sledge-hammer to crack a nut' all 3 approaches yield similar results. On a per ha basis, mechanized farms used more fertilizer, less pesticide and less labor and obtained higher yields. They were also

considerably larger than non-mechanized farms but had a lower cropping intensity. The yield differences are primarily due to these other factors rather than to any mechanization effects per se.

REFERENCES

Binswanger, H. P. 1978. "The Economics of Tractors in South Asia, an Analytical Review." Agricultural Development Council, New York and International Crops Research Institute for the Semi-Arid Tropic, Hyderabad, India.

Krishna, R. 1974. "Measurement of Direct and Indirect Employment Effects of Agricultural Growth with Technical Change." In Edgar O. Edwards, ed., Employment in Developing Nations, Columbia University Press.

Tan, Y.L. 1981. "The Impact of Farm Mechanization on Small-Scale Rice Production." M.S. thesis, University of the Philippines at Los Baños.

Table 1. Classification of 282 sample farms by type of power use in land preparation, West Java, Indonesia, wet season 1979/1980 and dry season 1980.

LAND PREPARATION				TYPE OF MECHANI-ZATION	NO. OF SAMPLE FARMS
Wet season		Dry season			
Plowing	Harrowing	Plowing	Harrowing		
T	T	T	T	T_1	62
M	M	M	M	M_1	50
A	A	M	M	A_1	50
T	T	T	M	T_2	35
A	M	M	M	M_2	35
T/A/M	T/A/M	A/M	A/M	T_3	50
					282

Note: T = handtractor; A = animal; M = manual.

T_1 = pure mechanized farms

M_1 = pure manual farms

A_1 = animal-manual farms

T_2 = mainly mechanized farms

M_2 = mainly manual farms

T_3 = unclassified farms

Table 2. Percentage distribution of sample farms by location and type of mechanization, West Java, Indonesia, 1980.

LOCATION	DISTRIBUTION OF SAMPLE FARMS (%) BY TYPE OF MECHANIZATION							
	T_1	M_1	A_1	T_1	M_2	T_3	Total	Percent
A. Indramayu								
1) Sukadana	17	5	1	-	1	6	30	10
2) Gabuskulon	2	4	1	12	10	8	37	13
3) Anjatan	13	5	3	-	6	6	33	11
4) Sukra	12	3	1	3	2	6	27	9
B. Subang								
5) Bojongtengah	4	10	30	1	1	3	49	17
6) Pamanukan	3	10	2	7	3	7	32	11
7) Mariuk	9	1	10	10	1	9	40	14
8) Tambakdohan	2	12	2	2	11	5	34	12
Total	62	50	50	35	35	50	282	100

Table 3. Test for differences of input utilization between mechanized (T_1) and unmechanized farms, West Java, Indonesia, 1979/1980.

VARIABLES	DIFFERENCE		
	T_1 vs M_1	T_1 vs A_1	T_1 vs M_2
	N use per hectare (kg)		
Wet season	- 1 (0.14)	23 (4.24)**	- 15 (1.63)
Dry season	- 1 (0.03)	7 (1.00)	- 9 (0.96)
Annual	- 6 (0.45)	27 (2.79)**	- 24 (1.49)
	TSP use per hectare (kg)		
Wet season	13 (1.49)	28 (3.72)**	- 10 (0.92)
Dry season	5 (0.54)	22 (2.97)**	1 (0.08)
Annual	19 (1.26)	50 (4.19)**	- 1 (0.11)
	Pesticide use per ha (Rp)		
Wet season	-572 (1.03)	-2632 (4.76)**	317 (0.67)
Dry season	-416 (0.61)	-1968 (2.90)**	-426 (0.66)
Annual	-928 (0.84)	-4212 (4.03)**	350 (0.28)
	Labor use per hectare (mds)		
Wet season	- 57 (7.58)**	- 34 (6.20)**	- 35 (6.77)**
Dry season	- 37 (4.85)**	- 27 (5.39)**	- 21 (3.17)**
Annual	-106 (6.64)**	- 62 (5.74)**	- 42 (4.72)**
	Labor use per farm		
Annual	396 (6.39)**	301 (4.93)**	324 (4.77)**

*,**Significant at 5 and 1 percent level, respectively.

Numbers in parentheses are t values.

Table 4 . Test for differences of input utilization between mechanized (T_2) and unmechanized farms, West Java, Indonesia, 1979/1980.

VARIABLES	DIFFERENCE		
	T_2 vs M_1	T_2 vs A_1	T_2 vs M_2
	N use per hectare (kg)		
Wet season	- 3 (0.27)	21 (2.61)*	- 17 (1.52)
Dry season	9 (0.98)	17 (1.88)	1 (0.08)
Annual	6 (0.31)	39 (2.73)**	- 12 (0.64)
	TSP use per hectare (kg)		
Wet season	15 (1.63)	30 (3.80)**	- 8 (0.70)
Dry season	20 (1.74)	37 (3.80)**	16 (1.53)
Annual	33 (2.04)*	64 (4.54)**	13 (0.94)
	Pesticide user per ha (Rp)		
Wet season	-798 (1.12)	-2858 (0.40)	91 (0.13)
Dry season	- 70 (0.09)	-1622 (2.00)	- 80 (0.09)
Annual	- 30 (0.22)	-3585 (2.66)*	977 (0.94)
	Labor use per ha (mds)		
Wet season	- 49 (6.42)**	- 26 (4.59)**	- 27 (4.79)**
Dry season	- 28 (2.67)**	- 18 (2.14)*	- 12 (1.21)
Annual	- 84 (4.01)**	- 40 (2.57)*	- 23 (1.49)
	Labor use per farm		
Annual	426 (4.23)**	331 (3.30)**	354 (3.39)**

*,**Significant at 5 and 1 percent level, respectively.

Numbers in parentheses are t values.

Table 5 • Test for differences of farm size, cropping intensity and production between mechanized (T_1) and unmechanized farms, West Java, Indonesia, 1979/1980.

VARIABLES	DIFFERENCE		
	T_1 vs M_1	T_1 ms A_1	T_1 vs M_2
Farm size (ha)	3.61 (7.98)**	3.01 (6.26)**	3.15 (6.33)**
Cropping intensity	-0.19 (4.00)**	-0.17 (3.57)**	-0.20 (3.94)**
Yield per hectare (kg)			
Wet season	411 (2.23)*	159 (1.02)	-401 (1.86)
Dry season	647 (2.58)*	974 (4.02)**	196 (0.71)
Annual	1102 (3.41)**	1225 (4.06)**	-155 (0.42)
Production per farm			
Per annum (kg)	27332 (8.33)**	22615 (6.70)**	22038 (6.18)**

*,**Significant at 5 and 1 percent level, respectively.

Numbers in parentheses are t values.

Table 6. Test for differences of farm size, cropping intensity and production between mechanized (T_2) and unmechanized farms, West Java, Indonesia, 1979/1980.

VARIABLES	DIFFERENCE					
	T_2 vs M_1		T_2 vs A_1		T_2 vs M_2	
Farm size (ha)	3.09	(6.65)**	2.49	(4.29)**	2.59	(4.49)**
Cropping intensity	-0.11	(2.26)*	-0.09	(1.78)	-0.12	(2.39)*
Yield per hectare (kg)						
Wet season	458	(2.03)*	206	(1.01)	-354	(1.34)
Dry season	531	(1.71)	858	(2.89)**	80	(0.24)
Annual	1096	(2.44)*	1219	(2.89)**	-161	(0.31)
Production per farm						
Per annum	26129	(4.86)**	21412	(3.95)**	20835	(3.76)**

*,**Significant at 5 and 1 percent level, respectively.

Numbers in parentheses are t values.

Table 7. Decomposition analysis of output differences between mechanized and unmechanized farms.

Effects	Percentage share					
	T_1 vs M_1	T_1 vs A_1	T_1 vs M_2	T_2 vs M_1	T_2 vs A_1	T_2
Sources of output differences						
A. Individual effects						
Yield effect	3.92	5.41	-1.52	5.43	8.21	
Area effect	96.91	99.99	122.83	86.82	87.40	10
Cropping intenstiy effect	-2.83	-4.93	-6.13	-1.71	-2.75	-
B. First order interaction effect						
Yield and area	13.12	9.69	-3.11	15.54	12.17	
Yield and cropping intensity	-0.38	-0.48	0.15	-0.31	-0.38	-
Area and cropping intensity	-9.46	-8.83	-12.54	-4.89	-4.08	-
C. Second order interaction effect						
Yield area and cropping intensity	-1.28	-0.85	0.32	-0.88	-0.57	-
Total	100.00	100.00	100.00	100.00	100.00	10

Table 8. Decomposition analysis of labor use differences between mechanized and unmechanized farms.

	Percentage share					
	T_1 vs. M_1	T_1 vs. A_1	T_1 vs. M_2	T_2 vs. M_1	T_2 vs A_1	T_2vsM_2
Source of labor use differences						
A. Individual effects						
Labor use per hectare effect	-20.62	-29.28	-25.71	-14.31	-17.02	-15.15
Area effect	206.86	202.49	200.77	164.61	152.25	153.39
Cropping intensity effect	-6.04	-10.12	-10.03	-3.25	-4.80	-5.50
B. First order interaction effects						
Labor use per ha and area	-68.81	-52.51	-52.52	-40.90	-25.26	-25.84
Labor use per ha and cropping intensity	2.05	2.62	2.64	0.80	0.79	0.90
Area and cropping intensity	-20.18	-17.81	-20.51	-9.26	-7.11	-9.40
C. Second order interaction effects						
Labor use per ha, area and cropping intensity	6.74	4.61	5.36	2.31	1.15	1.60
Total	100.00	100.00	100.00	100.00	100.00	100.00

Table 9. Cobb-Douglas production function with production per farm as dependent variable and two dummy variables.

Item	
No. of observation	596
R^2	0.87
F value	474.77
Regression coefficient of independent variables:	
Farm size (ha)	0.77 (10.36)***
Nitrogen (kg per farm)	0.22 (4.37)***
Trisuperphoshate (kg per farm)	0.06 (1.92)*
Insecticide (Rp per farm)	-0.07 (2.79)**
Labor (mandays per farm)	0.07 (1.10)
Mechanization dummy:	
T_1	0.03 (0.64)
T_2	-0.04 (0.73)
Intercept	6.83

Figures in parentheses are t values.

*,**,*** = significant at 5, 1 and .05 percent level respectively.

CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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 Owernship 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.

14. Tan, Y. L., J.P.G. Webster and J. A. Wicks. The Decomposition of Differences in Output Between Two Groups of Farms. Revised 1981.

17

15. Herdt, R. W. Mechanization of Rice Production in Developing Asian Countries: Perspective, Evidence, and Issues. September 1981.

16. Lantin, R. M. Mechanization Policy and the National Agricultural Mechanization Council - Philippines. September 1981.

17. Lockwood, B. Farm Mechanization in Pakistan: Policy and Practice September 1981.

18. Wiboonchutikula, P. The Total Factor Productivity Growth of the Three Digit Manufacturing Industries in Thailand. September 1981.

19. Ahammed, C. S. and R. W. Herdt. A General Equilibrium Analysis of the Effects of Rice Farm Mechanization in the Philippines. September 1981.

20. Mikkelsen, K. and N. Langam. Technology Change in the Philippine Agricultural Machinery Industry. September 1981.

21. Boughton, D. Energy Use in Alternative Rice Production Systems in Nueva Ecija, Central Luzon, Philippines. September 1981.

22. Hurun, A. Financial Analysis of Power Tiller Ownership in Mariuk Village, West Java, Indonesia. September 1981.

23. Hafsah, J. The Economics of Tractor Operation and Use in South Sulawesi, Indonesia. September 1981.

24. Maranan, C. L. A Comparative Analysis of Tractor Contract Operations in Nueva Ecija, Philippines, 1972 and 1980. September 1981.

25. Monge, V. S. and B. Duff. Analysis of the Demand for Farm Power for Small Rice Farm Agriculture in Nueva Ecija, Philippines. September 1981.

26. Munir, M. An Evaluation of the Farmers' Decision-Making for Investment in Farm Machinery. September 1981.

27. Jabbar, M. A., Md.S. R. Bhuiyan and A. K. Maksudul Bari. Causes and Consequences of Power Tiller Utilization in Two Areas of Bangladesh. September 1981.

28. Juarez, F. and R. Pathnopas. A Comparative Analysis of Thresher Adoption and Use in Thailand and the Philippines. September 1981.

29. Ahmed, J. U. Labour Use Pattern & Mechanization of Paddy Postharvest Processing in Bangladesh. September 1981.

30. Colter, J. M. The Impact of Handtractors on Income and Employment Opportunities of Migrant Laborers in Java. September 1981.

31. Santoso, K. The Potential for Agricultural Mechanization and Labor Markets in East Java. September 1981.

32. Bernsten, R. H. Effects of Mini-Tractor Mechanization on Employment and Labour Use Intensity, Sidrap and Pinrang, South Sulawesi, Indonesia. September 1981.

33. Collier, W. Improved Cropping Patterns, Labor Absorption and Small Farm Mechanization in Indonesia. September 1981.

34. Moran, P. B. and E. Camacho. Consequences of Farm Mechanization Project Site Description: Philippines. September 1981.

35. Generalla, A. C. and A. Aguilar. Effects of Mechanization on Intensity of Land Use. September 1981.

36. Tan, Y. and J. A. Wicks. Production Effects of Mechanization. September 1981.

37. Sison, J. F. and P. B. Moran. Farm Labor Utilization and Employment in Two Selected Municipalities in Nueva Ecija - A Preliminary Analysis. September 1981.

38. Saefuddin, Y. Site Description: Mechanization Consequences Project in West Java, Indonesia. September 1981.

39. Handaka, S. Effects of Mechanization on Intensity of Land Use, West Java, Indonesia. September 1981.

40. Handaka, S. A Technical and Economic Evaluation of Rice Mills in West Java, Indonesia. September 1981.

41. Sinaga, R. Effects of Mechanization on Productivity: West Java, Indonesia. September 1981.

42. Sinaga, R. Effects of Mechanization on Productivity: South Sulawesi, Indonesia. September 1981.

43. Sri-Bagyo, A. The Impact of Mechanization on Production and Employment in Rice Areas of West Java, Indonesia. September 1981.

44. Maamun, Y. Site Description: Mechanization Consequences Project in South Sulawesi. September 1981.

45. Sarasutha, I. G. P. and R. Bernsten. Effect of Mechanization on Intensity of Land Use, South Sulawesi, Indonesia. September 1981.

46. Bockhop, C. W. and M. Nafziger. The Impact of Economics upon the Design of Machinery at IRRI. September 1981.

47. Wattanutchariya, S. Economic Analysis of Farm Machinery Industry and Tractor Contractor Business in Thailand. September 1981.

48. Hussain, K. A. An Assessment of Capacity of Workshops and Farmers To Repair and Maintain Farm Machinery in District Faisalabad: Summary of Major Findings and Policy Recommendations. September 1981.

49. Gonzales, L. A. and R. W. Herdt. Evaluating the Sectoral Impact of Mechanization on Employment and Rice Production in the Philippines: A Simulation Analysis. September 1981.

50. Khoju, M. R. The Economics of Pump Irrigation in Eastern Nepal. September 1981.

51. Sudaryanto, T. The Effect of Tubewell on Income and Employment: A Case Study in Three Villages in Kediri, East Java, Indonesia. September 1981.

52. Santoso, K. Economics of Pumpsets in East Java. September 1981.

53. Wicks, J. A. and M. A. Sumiran. Data Management for Analyzing the Consequences of Mechanization. September 1981.

54. Webster, J. P. G. An Evaluation of Mechanization Data Using the FAO's Management Data Collection and Analysis System (FMDCAS). September 1981.

55. Lingard, J. Measuring the Impact of Mechanization on Output. September 1981.

JW/hhr