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THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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MYTHS ABOUT LAND PREPARATION MECHANIZATION: RESEARCH RESULTS IN INDONESIA

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MYTHS ABOUT LAND PREPARATION MECHANIZATION: RESEARCH RESULTS IN INDONESIA*

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INTRODUCTION

In most advanced industrial countries, farm mechanization has made a significant contribution toward increasing agricultural productivity. Consequently, it is natural for policy makers in developing countries to look toward mechanization to provide the same stimulus to their agricultural economies. Yet, it must not be forgotten that countries differ significantly in factor endowments. Consequently, the impact of a technology in one country can be significantly different than the impact of the same technology in another setting.

In 1978, USAID provided a grant to the International Rice Research Institute (IRRI) and the Agricultural Development Council (ADC) to establish cooperative research activities with Asian institutions to explore the "impact of small farm mechanization on production, incomes and rural employment". In Indonesia, the IRRI cooperators were Rural Dynamics Study, Agro-Economic Survey (RD/AES) in Bogor and the Maros Research

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Institute for Food Crops (MORIFC) in South Sulawesi. In addition, a staff member from the Sub-Directorate of Agricultural Machineries Development, Ministry of Agriculture and the South Sulawesi Extension Service were assigned to the project to provide technical support. The IRRI assisted part of the project involved surveying about 300 rice farmers over a two-year period at a site in West Java and another in South Sulawesi. The ADC component involved several small case studies conducted mainly by Indonesia university students, under the guidance of the ADC representative at the Bogor Agricultural University.

This paper summarizes results previously reported by participants in the Consequences Project and integrates these findings in order to make mechanization policy recommendations. We believe these results raise serious doubts as to the validity of much of the conventional wisdom that has been drawn upon in support of small farm mechanization in Indonesia.

ISSUES

In its basic form, advocates of land preparation mechanization for small rice farms argue that mechanization:

(1) Increases yield as a consequence of more timely and higher quality soil preparation.

(2) Increases cropping intensity by permitting more timely land preparation and shorter turn-around between crops.

(3) Increases area under cultivation where a shortage of labor results in land left fallow.

(4) Generates profits to rural entrepreneur/farmers who invest in mechanical power.

(5) Reduces human drudgery by eliminating the laborious task of manual and/or animal land preparation.

SITE SELECTION AND DESCRIPTION

Indonesia is a unique country in Asia because it is made up of areas with extremely high (Java, Bali) and extremely low (outer islands) population densities. Because we believed that this factor would have major implication for mechanization policy, a site was selected to represent each environment.

(1) West Java (Saefudin, 1981) - West Java, Subang and Indramayu Districts were chosen because they are major lowland rice areas and account for 34% of the hand tractors found in West Java. Subang and Indramayu are on the north coastal plain, 161 and 205 km., respectively, east of Jakarta. Population density averages 515 (Subang) to 577 (Indramayu) persons/km^2 and each district covers an area of about 1,900 $km.^2$ Taken together, about 53% of the agricultural land is classified as lowland (sawah) and 80% of this is irrigated. Irrigated farmers typically use the latest modern rice variety and apply 150-200 kg/ha of urea. Irrigated rice yields averages 5.0 t/ha in the wet and 4.0 t/ha in the dry seasons (1978). Two-wheel tractors were first introduced in the early 1970s and numbered 457 in 1979. In 1978, the total cow and carabao population was about

72,000 animals or 5.3 ha. of agricultural land/animal. While accurate data is not available, it is estimated that about 40% of the households in this area are landless.

A stratified sample of respondents was selected to reflect the agricultural diversity in the area. The final sample of 285 farmers was divided approximately equally between the four typical land preparation systems practiced: non-mechanized using manual labor, non-mechanized using animal power, mechanized by hiring hand tractor services and mechanized by self-owned hand tractor. The research staff lived in the villages and collected survey data during the 1979 dry (second crop), 1979 dry (third crop), 1979/80 wet (first crop), and 1980 dry (second crop) seasons. In addition, weekly record keeping was carried out during the first four seasons for 48 farmers and 12 landless laborers. Only data for the 1979 dry (second crop), 1979/80 wet (first crop) and 1980 dry (second crop) have been analyzed to date, so only these results are presented.

(2) South Sulawesi Maamun, 1981) - In South Sulawesi, Sidrap and Pinrang Districts were chosen because they are the leading areas for rice production and irrigated lowland in the province and account for 51% of the four-wheel mini-tractors found there. Sidrap and Pinrang lie about 200 km. north of the provincial capital Ujung Pandang. Population density ranges from 83 persons/km^2 in Sidrap to 108 persons/km^2 in Pinrang--each with slightly more than 100,000 ha of agricultural land. Taken

together, about 35% of the agricultural land is classified as lowland (sawah) and 67% of this is irrigated. Soils in this area are of high quality. Farmers typically use the latest modern rice variety and apply 100-150 kg/ha of urea. Lowland rice yields average 4.8 t/ha (Sidrap) and 4.4 t/ha (Pinrang) in the wet season (1976). Four wheel mini-tractors were first introduced in 1974 and the number of units grew to 508 by 1979. In 1978, the total carabao population was estimated at 23,643 or 8.8 acres/carabao. In contrast to Java, there are virtually no landless agricultural households in Sidrap-Pinrang.

As in West Java, a stratified sample of respondents was selected to reflect the agricultural diversity in the study area. The sample of 252 farmers was divided approximately equally between rainfed carabao users, rainfed mini-tractor users, irrigated carabao users and irrigated mini-tractor users. The research staff lived in the villages and collected survey data during the 1979 wet (first crop), 1979/80 dry (second crop), 1979/80 dry (third crop), 1980 wet (first crop), 1980/81 dry (second crop) and 1980/81 dry (third crop) seasons. In addition, weekly record keeping was carried out during the first four seasons for 70 farmers and an indepth survey was made of 50 tractor owners. Only the data for the first four seasons have been analyzed, so only these results are presented.

RESULTS

Data collected during the course of the research project is presented to evaluate the relationship between the hypothesized benefits of mechanization and the observed impacts.

(1) Yield effect. The effect of mechanized land preparation on yield is evaluated by comparing the yields obtained on non-mechanized and mechanized farms.

In West Java, mechanized farms had higher yields, the differences ranging from 62 kg/ha (W. S. 1979/80) to 586 kg/ha (D. S. 1980). Yet, crop failure due to a shortage of water was severe in the 1980 dry season, resulting in no harvest on 24% of the non-mechanized area. This impact was disproportionate because most of the non-mechanized farms happened to be in the villages affected by the water shortage. After adjusting for this effect, non-mechanized yields exceeded mechanized yields by 263 kg/ha. Furthermore, in all seasons, mechanized farmers applied 10-24 kg/ha more fertilizer than did non-mechanical farmers. Analysis showed that an average fertilizer productivity (response) assumption of 5.8 kg yield increase per kg of additional fertilizer would net out the higher yields observed on mechanized farms in the 1979 D. S. and 1979/80 W. S. No fertilizer productivity assumption is required in the 1980 D. S. since after adjusting for crop losses, non-mechanized yields already exceed mechanized yields (Sinaga, 1981a).

In South Sulawesi, yields on mechanized farms exceeded non-mechanized yields by 448 kg/ha in the 1979 W. S. and 197 kg/ha in the 1980 W.S. Yet, in the 1980/81 D.S., non-mechanized yields were 57 kg/ha greater. After compensating for differences in crop failure due to drought and insect pests, the yield differentials (mechanized above non-mechanized) fall to 402 kg/ha in the 1979 W. S. and increases to 227 kg/ha in the 1980 W. S. After making adjustment in the 1979/80 D. S., non-mechanized yields increased to 155 kg/ha above mechanized yields. As in West Java, mechanized farmers applied more fertilizer than their non-mechanized counterparts--ranging from 81-97 kg/ha more depending on the season. Analysis showed that average fertilizer productivity (response) assumptions of 4.1 kg (1979 W.S.) and 2.5 kg (1980 W.S.) per kg of fertilizer would account for the higher yields observed on mechanized farms. In the 1980/81 dry season, non-mechanized yields are already higher than mechanized, even though 81 kg/ha more fertilizer was applied on mechanized farms.

Even when considering only the raw yield data for both sites, the differences in yields between mechanized and non-mechanized is quite small. After adjusting for crop failure and fertilizer application intensity, the results suggest that there is no significant relationship between yield and type of land preparation.

(2) Cropping intensity - The cropping intensity effect is evaluated by comparing respondents cropping intensity before and after adopting mechanization and observing the impact of mechanization on the rate of land preparation.

In West Java for 1978-79, respondents who prepared their land manually had a cropping intensity of 2.07, compared to 2.14 for hand tractor users (Siswosumarto, 1981). In interpreting these results, it must be kept in mind that the planting of a third crop was new in the area--the consequence of the Government's IMPRES program to stimulate secondary crop (non-rice) production. Since tiller owners are larger landowners and community leaders, they are most likely to respond to the Government's initiative.

It is possible that hand tractors allow farmers to prepare their field more rapidly, permitting earlier crop establishment for both the first and second rice crop-thereby contributing to increasing cropping intensity. Yet, analysis of the data showed that in the 1979/80, W.S., the area prepared manually was completed most rapidly, followed by the area prepared by animal, hand tractor owners and hand tractor hire. This is a logical result since farmers who prepare their land manually have the smallest farms (1.0 ha vs. 5.5 ha for tiller owners) and typically hire labor to complete the job in a short time. In contrast, a hand tractor can plow less than 0.5 ha/day, returning

to harrow the field two weeks later. As a result, the elapse time required to prepare 5.5 ha with a tiller is about 35 days. Farmers hiring tillers have their land prepared last because owners till their own land before contracting to others. In the 1980 D. S., land prepared by tillers was completed 1-2 weeks before manually prepared land. This is because harvesting the first crop and preparing land for the second crop occur almost simultaneously in a given area. Because the wage earned for harvesting is 2-3 times higher than for land preparation, laborers choose to harvest before they accept land preparation contracts.

In South Sulawesi, we evaluate the data from a slightly different perspective, using more detailed farm record-keeping data. If adoption of mechanized power is a sufficient condition for increasing cropping intensity, farmers who adopt this technology should show an increase in cropping intensity after adoption. Among the 28 rainfed respondents who switched from animal to mechanical power for land preparation during 1974-1978, 28% increased their cropping intensity (Sarasutha, et. al., 1981). In contrast, among the 26 irrigated cooperators who adopted mechanized land preparation during the same period, none increased their cropping index.

In an attempt to determine if mechanization contributed to more rapid land preparation, the rate at which this task was

completed in the 1979 W.S. was evaluated. The data showed that in both rainfed and irrigated areas, the non-mechanized area was prepared more rapidly than the mechanized land. These results are due to the fact that most non-mechanized farmers use their own carabao which is always available for plowing. In contrast, most mini-tractor uses hire land preparation services from a tractor owner. Consequently, the mechanized farmers face a substantial queuing problem that delays their land preparation.

These results suggest that mechanization does not appear to be associated with increasing cropping intensity, except possibly in rainfed areas of South Sulawesi. In fact, the data suggest that due to the queuing problem, the spread of mechanization might actually lengthen the time required to prepare land in a given area.

(3) Area under cultivation - This effect is evaluated by analyzing the relationship between hand tractor/mini-tractor numbers and area cultivated.

In West Java, with a high man-to-land ratio we would not expect to find land left fallow due to a shortage of labor. Data published by the Central Bureau of Statistics (BPS) indicates a total harvested rice area of 140,144 ha in Subang in 1974 when 28

hand tractors were available, but a harvested area of 136,297 ha in 1979 when the tiller population had reached 197 units (Consequences Team, 1981). In Indramayu the harvested area increased steadily from 167,590 (1974) to 192,723 (1978). During this period, the number of hand tractors rose from 12 to 260. Yet, this harvested area increase was largely due to an increase in cropping intensity since the wet season rice area ranged from 115,300 to 118,100 ha from 1976 to 1979.

In South Sulawesi, where the man-to-land ratio is relatively low, we would expect a possible area expansion effect from mechanization. Yet, no consistent pattern is evident. For example, in Sidrap the wet season rice area increased from 37,040 ha in 1975 to 37,977 ha in 1978 during which the mini-tractor population rose from 76 to 151 (Consequences Research Team, 1981). Yet, the area in wet season rice increased from 37,977 ha in 1978 to 43,496 ha in 1979 as the mini-tractor population rose from 151 to 297 units.

As would be expected, the data suggests that in West Java, there is little evidence to suggest mechanization has led to area expansion. On the other hand, in South Sulawesi the year-to-year variability in area planted data is too great to draw any firm conclusion.

(4) Profitability - When tillers and mini tractors are introduced into a new area, potential buyers are typically unfamiliar with the capacity and income earning potential of the equipment. Often their purchase decision is highly influenced by assurances of dealers and extension personnel. Yet, unless the equipment proves to be reliable and profitable, it is unlikely owners will replace their units when they wear out.

For West Java a case study of 24 gasoline and 10 diesel hand tractor owners in one of our sample villages provides insights into the profitability of tiller ownership (Huran, 1981). The gasoline tillers evaluated were rated at 6.5 hp, purchased in 1978 or later and cost an average of $US 1,586. The diesel units were rated at 7.5 or 8.5 hp, mostly purchased in 1979 or 1980, and cost an average of $US 3,737 each. These gasoline units prepared on the average 24 ha/year and the diesel tillers 26 ha/yr -- two-thirds of the work being performed in the wet season.

Breakeven analysis showed that assuming a useful life of five years (3,000 hours), the gasoline units must prepare 21 ha/year and the diesel 38 ha/year to cover fixed and variable costs—excluding any return on the capital investment (profit). The internal financial rate of return on gasoline tillers was 7.2%, slightly below the subsidized interest rate of 10.5%/year.

On the other hand, for diesel owners, the internal rate of return was less than 1%.

While these results suggest that gasoline tillers almost covered interest, fixed and variable costs, they generated no profit to the investor. Furthermore, these results must be re-evaluated in light of recent increases in tiller prices. The sample of respondents paid an average of $1,752/unit, compared to the new price of $2.566 (1981). At this new price, the breakeven hectarage rises to 31 ha/year. If owners paid a modest interest rate of 20%/year on their tiller loan and the fuel subsidy was removed, gasoline tillers would have to prepare over 40 ha/year to breakeven--compared to the actual performance of 21 ha/year observed in the sample of respondents.

For South Sulawesi a case study of 50 mini-tractor owners provides insights into the economics of ownership (Hafsa, et. al., 1981). The mini-tractors evaluated were rated at 12-15 hp, ten units were purchased in 1975, 1976, 1977, 1978 and 1979 and cost an average of $US 5,513. Capacity utilization was highest in the first year of use for units bought in each year. Furthermore, the realized capacity for new units fell each year. For example, the ten units purchased in 1975 averaged 102 ha in that year, but those purchased in 1979 only plowed an average of

57 ha in 1979. Generally, 60% of the hectares plowed were done in the wet season.

Breakeven analysis showed that assuming a useful life of five years, fixed and variable costs were covered in only one of the five years the 1975 vintage units operated, three of four years for the 1976 vintage, and one of two years for the 1978 vintage units. Owners of units bought in 1977 and 1979 did not cover cost in any year. Benefit cost was approximated as gross revenue/season divided by total costs/season. The benefit cost ratio only exceeded 1.0 for 1976 vintage models in three of four years and for 1978 vintage units in only one of two years. In both the breakeven and benefit cost analysis, no return on capital was included as a cost.

These results are based on actual cost in the year of purchase which rose from about $US4,500 in 1976 to $US5,900 in 1979. During this period, the contract plowing rate increased from $US 18.82 in the 1975 W.S. to $US44.70 in the 1978 D.S. Yet, the contract rate fell to $US37.20 in the 1979 D.S. and still lower to $US25.00 in the 1979 D.S. While we can expect the cost of these units to increase each year, the observed fall in the contract plowing rate and decline in the average hectares plowed/unit for each year from 1975 to 1979 suggests the supply of mini-tractor services exceeds the demand—making it impossible

for new owners to cover their costs. As this analysis was based on Government subsidized interest rates (12%/year) and subsidized fuel prices, the results would be even less favorable if these subsidies were withdrawn.

These two studies indicate that in both West Java and South Sulawesi, at current tractor prices, new owners cannot cover fixed and variable costs—no less make a profit on their investment. In West Java, the contract rate cannot exceed the rate for manual land preparation or farmers would be unwilling to hire tiller services. The prevailing low wage rate (typically $US1.00/day) for land preparation is the consequence of high population density and a surplus of labor relative to demand. Consequently, the only way tiller owners can cover costs is to increase the utilization capacity. Yet, these small units require about 22 hours to prepare one hectare (Huran, 1981). Consequently, it is almost impossible for these units to cover enough hectares to break even as the land preparation period only lasts for 4-6 weeks in a given area. In South Sulawesi, the root of the problem seems to be that the number of mini-tractors introduced exceeds the demand for contract services, resulting in a decline in the contract rate below the level required to cover costs. In addition, the increase in tractor numbers has meant that each new owner competes for a share of a relatively fixed

area to be plowed--resulting in each unit plowing fewer hectares each season.

(5) Drudgery - It is often suggested that land preparation is extremely difficult work. Therefore, efforts must be made to mechanize this operation to reduce human drudgery.

In West Java, farms that use only manual labor for land preparation required about 54 work days/ha of labor in the wet season and 31 workdays/ha in the dry season (Consequences Research Team, 1981). Eighty percent of this labor was hired--mainly provided by the landless--in both the wet and dry seasons. In contrast, mechanized farms required 21-16 and 19-21 workdays/ha of manual labor for land preparation in the wet and dry seasons, respectively--over 90% of which was hired. These data show that tillers do not allow persons previously doing manual labor to become tiller users. Quite to the contrary, the adoption of tiller results in about a 50% reduction in the workdays available to laborers. In a dynamic rural economy where there is a shortage of labor, the reduction in labor requirements/ha would have a positive impact. Yet, a recent study (Bernsten, et.al., 1980) in two villages in Karawan, West Java (near the mechanization study site) found that between the 1974/75 and 1978/79 wet seasons, real manual land preparation wages (money wage divided by the rural index of nine essential

commodities) fell by 10%. This results raises doubt as to the validity of the hypothesis that labor displaced by land preparation mechanization will be absorbed in other sectors.

In South Sulawesi, in 1979, about 40% of the 39 workdays/ha of human labor used for land preparation on rainfed non-mechanized farms was hired, but on irrigated farms only 14% of the 20 workdays/ha required was hired. On mechanized rainfed farms, total human labor used for land preparation was 20 workdays/ha on mechanized irrigated farms (33% hired). On rainfed farms in South Sulawesi, mechanization reduces by about two-thirds hired labor required for land preparation, but also reduces the family labor input by about one-third. On the irrigated mechanized farm, the main effect is that mechanization reduces family labor requirements by about 70%. Consequently, we see that since hired labor constitutes a small share of total land preparation labor, mechanization permits a farmer to substitute capital for his labor--reducing the drudgery of manual labor.

As would be expected, the mechanization of land preparation has a positive impact in South Sulawesi because labor on these farms is largely supplied by the household. In contrast, in West Java where land preparation labor is mostly provided by hired landless laborers, mechanization does not reduce the drudgery to

those who perform the task -- rather, it eliminates work opportunities in a rural economy where new employment options appear to be lacking.

POLICY RECOMMENDATIONS

The results presented are based on a preliminary analysis of data generated by a two-year study of the consequences of mechanization in densely populated West Java and sparcely populated South Sulawesi. Presently, several Ph.D. and M.S. students are using these data sets in meeting thesis requirements. These studies are intended to evaluate in greater depth the issues covered in this paper and related policy questions. These studies will become available during the next twelve months.

While our approach to analyzing the issues raised has not involved the use of sophisticated analytical models, we feel that there exists sufficient evidence to raise considerable concern as to the impact of small farm land preparation mechanization in Indonesia. Yet, in recent years, the scientific community has come to acknowledge that before introducing a new technology (i.e., before building a dam or introducing a new drug), the advocate has the responsibility of showing evidence that the intervention will have a positive social impact. We contend that

this is an appropriate philosophical perspective that should be used as a frame of reference in making mechanization policy.

We recognize that in some areas of Indonesia and at some point in time, the mechanization of land preparation and other farm operations will be necessary and appropriate. Consequently, mechanization policy must be flexible to accommodate regional needs and changing factor endowments. In addition, efforts should be made to remove the major constraints that have been responsible for the disappointing performance of tillers and mini-tractors. Appropriate Government policies might focus on the following areas:

(1) Subsidies - Presently, tillers and tractors are made available to farmers at subsidized interest rates. Given that there is evidence to suggest that widespread adoption of these units will have a serious impact on job opportunities for the landless, especially in the inner islands, these loans should be made at commercial rates.

(2) Appropriate tillers/tractors - The units presently being imported into Indonesia are sophisticated pieces of machinery that are both expensive and subject to frequent breakdown. Efforts should be made to identify cheaper and more robust models that would make it possible for owners to operate

them profitably at prevailing contract plowing rates and reasonable levels of capacity utilization.

(3) Monitoring - Responsibility for monitoring the impact of tiller/tractor introduction must be given to a capable agency sensitive to the issues involved. Information gathered would provide a sound basis for future policy decisions.

(4) Repair and maintenance - In both sites, farmers had bought several different brands of tillers/tractors. Farmers faced considerable difficulty in obtaining spare parts and having repairs made. This constraint could be remedied by reducing the number of brands sold at a given site and requiring that dealers maintain both spare parts and repair shops at locations where tillers/tractors are being introduced.

(5) Custom plowing - Few farmers have enough land to achieve an economic level of utilization on their own land or the maintenance skills needed to extend the life of a tiller/tractor to its maximum. Consequently, it may be appropriate in areas where additional power is needed, for the Government to encourage the establishment of private firms or dealers to provide private contract plowing services to farmers at non-subsidized rates.

(6) Promotion - Because few farmers have sufficient experience to evaluate the profitability of machinery ownership, they rely heavily on dealers and the extension service for

advice. Efforts should be made by the extension service to assist potential buyers to evaluate their power needs and the level of capacity utilization that must be achieved to cover fixed and variable costs.

(7) Farm management training - Few purchasers of tillers/tractors have adequate accounting expertise to maintain records and evaluate the profitability of machinery ownership. Dealers should be required to provide training to new owners that would enable them to continually evaluate the profitability of their investment. Extension staff should also be trained in basic accounting skills so they can assist owners in maintaining proper records after purchasing the tiller/tractor.

(8) Labor mobility - It is probable that in some locations, at peak land preparation periods, labor bottlenecks will occur. An appropriate agency should take the responsibility for monitoring land preparation activities and alerting potential job seekers (possible over the radio) as to where laborers are needed. An effort such as this would increase the mobility of labor in a fragmented job market and better equate the supply of and demand for land preparation labor.

The myths about the benefits of land preparation/mechanization are persuasive because in some settings, under specific circumstances at given points in time, these effects have been

observed. The challenge to agricultural scientists and policy makers in Indonesia is to adopt a systems analysis approach directed at determining how to stimulate rural development and increase rural welfare, taking into account prevailing environmental features, resources available to farmers, and institutional factors—all phenomena that will determine the ultimate impact of mechanization in Indonesia.

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