ABSTRACT

Farm Mechanization Strategies in an Economy-Wide Model: Indonesia

C.S. Ahammed and Bart Duff

Respectively USAID Bangladesh, and International Rice Research Institute

Modernization in agriculture has the potential for developing large growth-inducing linkages with other sectors of the economy. Such linkages arise primarily because the new agriculture production technology requires purchase of current and capital inputs and, more importantly, because of the increase in demand for goods and services produced in other sectors of the economy. Employing a modified version of the Social Accounting Matrix (SAM), this paper examines the degree and composition of production and consumption linkages between agriculture and other sectors of the Indonesian economy. It was found that because of its size, the rice sector offers enhanced opportunity for increases in employment through changes in consumption expenditures arising from substitution among alternative production patterns. Further exploration of these patterns suggests that income to hired labor. Development strategies focusing on these linkages can be highly complementary with the growth and long run equity in development.

ABSTRAK

Strategi Mekanisasi Pertanian dalam Model Ekonomi Keseluruhan: Indonesia

C.S. Ahammed dan Bart Duff

Berturut-turut dari USAID Bangladesh dan IRRI

Modernisasi di bidang pertanian mempunyai potensi untuk mengembangkan hubungan pertumbuhan yang besar dengan sektor ekonomi lain. Hubungan semacam ini timbul terutama karena teknologi baru tersebut membutuhkan pembelian untuk biaya modal dan operasi, serta yang lebih penting lagi, karena adanya peningkatan permintaan terhadap barang dan jasa dari sektor ekonomi lain. Dengan menggunakan versi SAM (Social Accounting Matrix) yang dimodifikasi, makalah ini menguji derajat dan komposisi hubungan produksi dan konsumsi antara sektor pertanian dengan sektor ekonomi Indonesia yang lain. Diperoleh kesimpulan bahwa karena ukurannya yang besar, sektor padi menawarkan kesempatan peningkatan kesempatan kerja melalui perubahan pola konsumsi yang timbul akibat adanya substitusi di antara pola produksi alternatif. Pembahasan lebih lanjut terhadap pola ini memperlihatkan bahwa hubungan konsumsi yang paling besar terdapat pada sektor yang memberi pendapatan yang relatif lebih besar kepada tenaga buruh. Strategi pengembangan yang dititikberatkan pada hubungan ini dapat sesuai dengan pertumbuhan dan pemerataan jangka panjang yang serasi.

Production and consumption linkages arise because modern farm production technologies require increased purchase of current and capital inputs, and because the resulting rise in farm income will lead to a large increase in consumption expenditure[4]. The strength of the linkages depends on the distribution of income from rice production and the consumption propensities of various earners. Import substitution in production and consumption also affects the linkages. We have developed a variant of the Social Accounting Matrix (SAM) model to explore these effects. Weisskoff (1971) calculated employment effects for alternative import substitution and export promotion strategies using conventional input-output analysis. Thorbecke et al (1972) checked the feasibility of full employment, and Krishna (1975) measured direct and indirect employment effects of growth and technical change in the farm sector using a conventional input-output model. Paukert et al. (1975) used SAM methodology later developed by Pyatt and Round (1977 and 1979) to present empirical results of the links between changes in income distribution and changes in employment. Bell and Hazell (1980) used the SAM approach to measure indirect effects of an agricultural investment project on its surrounding region. We extend these earlier approaches by identifying and measuring the effects of a series of different technologies for rice production.

METHODOLOGICAL CONSIDERATIONS[5]

The basis for our analysis is the national input-output matrix for Indonesia. Alternative technological strategies for rice production are reflected by separating the rice sector in that matrix into 18 subsectors, differing by level of farm mechanization and associated water-topography (Table 1). In a similar way the agricultural machinery sector is separated into 5 subsectors comprised of 7 rice production machines (Table 2). Five groups of consumers, with different consumption parameters and different resource ownership patterns are defined.

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[4]Mellor (1976) stresses the consumption linkages in a somewhat broader development context.

[5]The methodology described here is a slight modification of that used in an earlier, similar analysis of the impact of mechanization on Philippine rice production (Ahammed and Herdt, 1983b).

Table 1. Eighteen technological options for rice production in Indonesia.

Sub-sector system	Irrigation	Land Preparation	Weeding & transplanting[a]	Harvesting & threshing[b]	Assumed yield (kg/ha)	Assumed cropping intensity	Assigned proportion of paddy produced
							%
1	Dryland	Buffalo	man.	man.	1500	90	6
2	Rainfed	Buffalo	man.	man.	2000	90	31
3	Rainfed	Power tiller	man.	man.	2000	100	8
4	Gravity I	Buffalo	man.	man.	3800	200	20
5	Gravity I	Buffalo	w + t	r + t	3800	220	1
6	Gravity I	Power tiller	man.	man.	3800	220	3
7	Gravity I	Power tiller	man.	r + t	3800	230	1
8	Gravity I	Power tiller	w + t	r + t	3800	240	1
9	Gravity II	Buffalo	man.	man.	4800	250	18
10	Gravity II	Buffalo	w + t	r + t	4800	275	1
11	Gravity II	Power tiller	man.	man.	4800	275	3
12	Gravity II	Power tiller	man.	r + t	4800	288	1
13	Gravity II	Power tiller	w + t	r + t	4800	300	1
14	Pump	Buffalo	man.	man.	4800	250	1
15	Pump	Buffalo	w + t	r + t	4800	275	1
16	Pump	Mini tractor	man.	man.	4800	275	1
17	Pump	Mini tractor	man.	r + t	4800	288	1
18	Pump	Mini tractor	w + t	r + t	4800	300	1

[a] man. = manual; w+t = human-powered mechanical weeders and transplanters
[b] man. = manual; r+t = power-driven reapers & mini-threshers

Table 2. Seven agricultural machines making up five machinery sectors.

Sub Sector	Type of Machinery	Description	Cost to farmer (Rp)	Horsepower
1.	Power tiller	2-wheel with rotovator	1 250 000	6 (diesel)
2.	Mini-tractor	4-wheel and rotovator	4 500 000	13-14 (diesel)
3.	Weeder	Manually operated IRRI type	8 000	-
3.	Transplanter	Manually operated IRRI type	180 000	-
4.	Reaper	HT- IRRI type	200 000	6 (gasoline)
4.	Thresher	HT-6 IRRI type	500 000	5 (gasoline)
5.	Irrigation pump	6 inches-axial flow	365 000	5 (gasoline)

Specifiying which system produces what amount of final demand, the model uses semi-closed input-output relations to compute the domestic production and the intermediate imports required to meet the demand. The factor shares of production determine the distribution of income among owners of factors, which in turn affects the volume and pattern of private consumption and savings. Finally, the model computes the corresponding employment and personal income of each consumer group. Comparison of the results obtained with varying proportions of total rice area cultivated by the 18 subsectors provide a measurement of the effects of moving toward different patterns of technological innovations.

The Indonesian Bureau of Statistics (BPS) 66 sector input-output model (1980) was consolidated into a 33 x 33 sector model. The disaggregation of the rice and agricultural machinery sectors was added to that 33 x 33 matrix to give an input-output table of 54 x 54 sectors. The augmented matrix (54 x 54) met two criteria: the individual technological coefficients in the rice and farm machinery sub-sectors had to be consistent with known differences, and they had to aggregate into national technological coefficients (for rice or farm machinery) equal to the sectoral coefficient that appears in the original input-output table.

We distinguish five household classes to incorporate the income distribution, consumption, saving and import substitution effects of technological innovations. For rice farm households, our definitions rest on endowments of land, labor and capital; the other household classes are defined as non-rice farm households and non-farm households.

The first class, hired labor households, derive their income from labor services in rice farming. Landowner households include farmers as well as landlords. Their incomes consist of the returns from land and capital. Farm operator households are defined as renters of land, and obtain earnings from both capital and labor. Incomes of non-rice farm and non-farm households are assumed to depend on gross output produced in these sectors.

The Model

Five groups of equations comprise the model: production and household consumption, imports, saving, income and employment.

The first set achieves material balances among all production sectors, and household classes. The equations are built around fixed input-output and household expenditure coefficients. Distribution of consumption expenditures (for domestic items) by household classes results from the assumptions of a consumption function, in which the expenditure share of a given commodity in the total (pre-tax) income of the household remains constant.

Imports are disaggregated in two groups: imports for intermediate use and imports for consumption. Both groups of imported goods are fixed in proportion to sectoral outputs and household incomes respectively.

Savings are defined as a residual obtained by subtracting consumption expenditure on domestic and imported items from (pre-tax) gross income. It therefore follows that total expenditure on private consumption (domestic and imported items) plus private savings in each household class is equal to total income of the class.

Gross value added in each of the rice systems is allocated as payments to operators, laborers and landlords. These payments determine income for the first, second and third groups of household classes. Non-rice farm income and non-farm income are assumed to be fixed proportions of total output in these sectors. Income components generated for each of the household classes per unit of sectoral output produced are assumed to remain constant.

Employment in each sector is assumed to be determined by fixed sectoral labour-output ratio. Total employment is obtained by summing employment of all sectors.

In its most general formulation the variant of the SAM model discussed above can be written as:

$$Q.R = Z, \tag{1}$$

where Q is a 62 x 62 square matrix of structural coefficients

R is a 62 x 1 column vector of the endogenous variables

Z is a 62 x 1 column vector of the exogenous variables;

The solution is obtained as:

$$R = Q^{-1}.\ Z. \tag{2}$$

The components of the Q, R and Z matrices are:

$$\underset{[Q]}{\left(\begin{array}{cccc} I-A & 0 & -C_c & 0 \\ \hline -A_m & & -C_m & \\ & I & & 0 \\ 0 & & -C_s & \\ \hline -A_k & 0 & I & 0 \\ \hline -A_l & 0 & 0 & I \end{array}\right)} \cdot \underset{[R]}{\left(\begin{array}{c} X \\ \hline M \\ \\ S \\ \hline Y \\ \hline L \end{array}\right)} \quad \underset{[Z]}{\left(\begin{array}{c} F \\ \hline \\ 0 \\ \\ \hline 0 \\ \hline 0 \end{array}\right)} \tag{3}$$

Where:

- X is a 54 x 1 vector of outputs, X_j.
- A is 54 x 54 square matrix of technological coefficients, with elements a_{ij} defined as:

$$a_{ij} = x_{ij}/x_j \quad (i, j = 1, 2, ..., 56), \tag{4}$$

where X_{ij} is the intermediate delivery of sector i to sector j.

- Y is the 5 x 1 vector of household class incomes, y_k.
- C_c is a 54 x 5 rectangular matrix of domestic consumption coefficients with elements c_{ik} defined as:

$$c_{ik} = e_{ik}/y_k \quad (i = 1, 2, ..., 54 \quad k = 1, 2, ..., 5), \tag{5}$$

where e_{ik} is the expenditure on private consumption of domestic commodity i by household class k.

- F is 54 x 1 vector of exogenous final uses such as government consumption, stocks, exports and imports.
- A_m is a 1 x 54 vector of intermediate import coefficients with elements a_{mj} defined as:

$$a_{mj} = m_j/x_j \tag{6}$$

where m_j is intermediate imports by sector j.

- C_m is a 1 x 54 vector of private consumption of imported goods defined as:

$$m_{ck} = e_{mk}/y_k \tag{7}$$

where e_{mk} is private consumption of direct imports in the kth household class.

- C_s is a 1 x 5 vector of private savings with elements c_{sk} defined as:

$$c_{sk} = s_k/y_k \tag{8}$$

where s_k is private savings for the kth household class defined as a residual:

$$s_k = y_k - \sum_{i=1}^{54} c_{ik} - c_{mk}. \tag{9}$$

- A_k is a 5 x 54 rectangular matrix of income coefficients with elements a_{kj} defined as:

$$a_{kj} = y_k/x_j \tag{10}$$

- M is total imports
- S is total savings
- L is total labor employment
- A_l is a 1 x 54 vector of labor coefficients with elements a_{lj} defined as:

$$a_{lj} = l_j/X_j \tag{11}$$

  where l_j is employment in the jth sector.

The elements of the main diagonal of matrix Q are positive. The remaining non-zero elements are negative. We can therefore expect that matrix Q will have an inverse.

The Modified Model

The SAM model discussed above is based on the assumption of perfectly elastic supplies in all sectors. This assumes that each sector faces constant average costs as well as perfectly elastic supplies of all inputs and resources. This may be realistic for imports and small-scale manufacturing and service activities and capital-intensive manufacturing and infrastructure services. These sectors cannot easily respond to increased demand in the short run, and much of the increased demand is likely to be translated into price increase, at least until sufficient investment has been made to increase supplies. One feature of the Bell-Hazell (1980) study was a modification of input-output methods to enable a choice of fixing either the output or the export level for each sector. Following their method one can choose to assume for each sector that supplies are either perfectly elastic or perfectly inelastic. The latter assumption may be more relevant for primary activities and capital intensive non-farm activities, whereas the perfectly elastic assumption may be retained for other sectors.

Let the primary activities and capital intensive non-farm sectors be denoted by subscript p. (These include other farm-food crops, agricultural crops, buffalo services, fishery and livestock products, forestry, mining and quarrying, sugar refining, paper products and printing, petroleum products, cement, basic metal and metal products, electricity and gas manufacture and irrigation investment). The remaining sectors are denoted by subscript v[6]. The following rearrangement of our original model (Eq. 3) can be made:

$$
\left(\begin{array}{ccccc}
I-A_{vv} & 0 & 0 & -C_{cv} & 0 \\
\hline
-A_{pv} & -I & 0 & -C_{cp} & 0 \\
\hline
-A_{mv} & & & -C_{m} & \\
 & 0 & I & & 0 \\
0 & & & -C_{s} & \\
\hline
-A_{kv} & 0 & 0 & I & 0 \\
\hline
-A_{lv} & 0 & 0 & 0 & I
\end{array}\right)
\left(\begin{array}{c}
X_{v} \\
\hline
F_{p} \\
\hline
M \\
\\
S \\
\hline
Y \\
\hline
L
\end{array}\right)
=
\left(\begin{array}{ccccc}
I & A_{vp} & 0 & 0 & 0 \\
\hline
0 & -I+A_{pp} & 0 & 0 & 0 \\
\hline
 & A_{mp} & & & \\
0 & & 0 & 0 & 0 \\
 & 0 & & & \\
\hline
0 & A_{kp} & 0 & 0 & 0 \\
\hline
0 & A_{lp} & 0 & 0 & 0
\end{array}\right)
\left(\begin{array}{c}
F_{v} \\
\hline
X_{p} \\
\hline
\\
0 \\
\\
\hline
0 \\
\hline
0
\end{array}\right)
\qquad (12)
$$

Equations 3 and 12 are utilized to obtain our empirical results.

To measure employment generated by the consumption and production linkages of the modern technologies in rice we proceed as follows: First, we simulate the complete model as expressed in equations 3 and 12 with an exogenous increase in consumer demand for

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[6]Unlike other primary activities, rice production has a perfectly elastic supply. This exception is dictated by our method of model simulation-- an exogenous increase in rice consumption met from a given rice sub-sector.

rice fully met from the first sub-sector. The matrix is then inverted and finally post-multiplied by the constant vector (matrix) of exogenous variables in order to obtain the solution vector. The same process is followed for each of the 18 sub-sectors. This gives 18 simulations for 18 sub-sectors; in each the c_{ik} parameters for the relevant rice sub-sector i are increased to accommodate the shift in consumption expenditure in rice. Numerical values computed in selected pairs of simulations are subtracted from each other to measure the change that would occur if production took place in one rather than another sub-sector. Then, we consider a subset of the model relationships containing equations for production and employment[7], and simulate the effect of an exogenous increase in consumer demand for rice fully met from each sub-sector in turn. We again have 18 simulations; in each the household consumption components in vector F are increased to reflect the shift in consumption for the relevant rice sub-sector. Comparison of employment in two simulations allow total effects to be decomposed into production and consumption effects.

The study is a static comparative simulation exercise, measuring employment generated by consumption and production linkages under alternative assumptions about water control, topography and degrees of mechanization. We use a system of exclusively linear homogenous equations which allows us to obtain solutions by simple matrix inversion operations.

The most important limitations of the model are assumptions of fixed coefficient production function, unitary elasticities of demand, constant returns to scale, free labor force resources and non capacity limitations, and no balance of payment limitations.

DESCRIPTION OF DATA

The rice production technological options specified (Table 1) are as follows:

- Land preparation : water buffalo/power tillers/mini-tractor
- Weeding : manual/human-powered mechanical weeder

[7]The vector of household consumption is excluded from the first set of relationships, and household consumption is added to the final demand vector F.

- Transplanting : manual/human-powered mechanical transplanter
- Reaping : manual/power-driver reaper
- Threshing : manual/power-driver mini-thresher.

These are combined to form 5 successively higher levels of mechanization within four water regimes -- rainfed, simple gravity (gravity I), improved gravity (gravity II) and pump. The first is non-mechanized, the fifth is fully mechanized, while the second, third and the fourth are intermediate. One additional non-mechanized dryland system is included. Input-output data on the systems were based on data obtained from a number of farm level studies by the agronomy department of Indonesia's Central Research Institute of Agriculture (CRIA, 1981), the Survey Agroekonomi (SAE, 1980), the Central Bureau of Statistics (BPS, 1978a, 1980 and 1981).

The cropping intensity indices for the rice sub-sectors are shown in Table 1. They were computed on the assumption that while power tillers and mini-tractors increase cropping intensity by 10%, weeder, transplanter, reaper and thresher each increase cropping intensity by 2.5%.

A budget was developed for each of the rice production systems, showing the breakdown of costs and the earnings accruing to hired labor, farm operator, and landowner. Total value of output was allocated to intermediate inputs, labor earnings, fuel and lubricants, and machinery.

Cost of agricultural machinery use was separated into (i) depreciation, (ii) returns to capital, (iii) fuel and lubricants, (iv) repair, and (v) labor costs. Repair costs were assumed to consist of labor and capital in the same proportion as for the original machine.

The returns to land, labor and capital are apportioned to household classes in the following manner. Landowners' income equals rent on land, 50% of capital consumption and family labor allowances. Capital consumption allowance includes returns to capital for both the machinery and the spare parts plus interest charges. Income of hired labor households is the value added by hired labor. The income of operator households correspond to the residual 50% of capital consumption and family labor allowances. Indirect taxes are subtracted from each cost component and aggregated to show indirect taxes collected from rice production. Tax and tariff rates on agricultural inputs and machinery were obtained from tariff and customs codes of Indonesia.

A budget showing intermediate and primary costs involved in the construction of each of the 5 agricultural machines was developed based on data obtained from the Sub-Directorate of Mechanization, (Ditprod-IRRI), Indonesia. Small scale machines such as power tillers, threshers, weeders, transplanters, and reapers are domestically manufactured with imported engines; mini-tractors and irrigation pumps are imported either partly or completely knocked down.

The data on consumption patterns of household were obtained from the 1975 family income and expenditure survey of the Survey Sosial Ekonomi Nasional (1976). The five household classes in the model are assumed to correspond to five income classes in the survey: landowners to the income range Rp 40.000 - 50 000 (the highest 5% of rural households); operators to the range Rp 10,000 - 15,000 (the median group of rural households); hired labor to the range Rp 1000 - 5000 (the lowest 5% of rural households); non-rice farm households to incomes of Rp 15 000 - 20 000 (average rural households); and non-farm households to incomes of Rp 20 000 - 25 000 (average income of urban households). The model requires us to distinguish consumption expenditure on each item by household classes. For this purpose, consumption items were separated from the original 18 categories of the 1976 Family Income and Expenditure survey into a 33-category breakdown to correspond to the 1978 input-output table.

Import data are taken from 1980 foreign trade statistics of Indonesia published by BPS. Information on imports for intermediate uses by sector were obtained from the 1980 input-output accounts of Indonesia. The data on import propensities of consumption for different household classes are estimated from the 1976 Family Income and Expenditure Survey.

Savings and taxes include personal plus corporate savings and direct plus indirect taxes. Data on aggregate savings and taxes are obtained from national income accounts (BPS, 1981). The aggregate savings and tax figures are disaggregated into separate household classes using the 1976 Family Income and Expenditure Survey.

Data on the labor force are taken from the National Labor Force Survey (SAKERNAS, 1976) and the Intercensal Population Survey (SUPAS, 1976). The data include both the unemployed and employed labor force.

MODEL SIMULATIONS AND RESULTS

The model simulations consider an increase in consumer spending for rice equal to the amount produced on 1000 ha of land in each rice production sub-sector in turn. The difference in the results obtained by increasing the output from one sector compared to another provides an indicator of the impact of the selected sector. Due to space limitations we present results of 12 selected comparisons, arranged in ascending order of mechanization so that a comparison within a given water regime yields the production and consumption effects of mechanization. Comparison across water regimes reflects the production and consumption effects of irrigation (not shown).

Employment Effects of Mechanization

Employment in the rice sector consists of both family and hired labor. However as non-rice employment is calculated from labor coefficients in the national input-output table it refers to hired labor only. A change in employment arising from mechanization is the consequence of production and consumption effects. Production effects are separated into three components: first-round direct effect that refers to initial change in employment in the rice sector due to machine use; equilibrium direct effect that refers to employment in the rice sector arising from subsequent production and consumption linkages for rice; and indirect effect that shows labor employment in the non-rice sector by "backward" and "forward" production linkages. Consumption in non-rice sectors arising from the income flow from a given level of technology, taking into account possibilities of import substitution in consumption.

Power tiller and mini-tractor. Consumption and production effects of employment that arise from mechanization under various water regimes are shown in Table 3. The results (first row) indicate that if the increased rice hectarage is attained by increasing production from an irrigated sub-sector using a power tiller rather than a buffalo, employment would increase five to fifteen times that of a similar change in land preparation power source under rainfed conditions. As expected, the first-round direct employment effect of moving from buffalo to power tiller/mini-tractor is always negative, and the decline is largest in rainfed systems. The equilibrium direct effect comprising subsequent production and consumption linkages for rice demand is always positive, and offsets the initial decline in employment. The equilibrium direct effect is strongest in pump-irrigated regimes, and weakest in rainfed systems. The indirect production effect showing labor employment in non-rice sectors is generally positive, and increases with irrigation intensification. The negative direct effect of adopting miniptractors in pump irrigation systems is explained by high import leakages of inputs. The increase in employment seems to depend to a great extent on the consumption linkages, which are much higher in the irrigated regimes because of increased use of labor in land preparation. If the consumption linkages were ignored, as happens in conventional analysis, the net effect on employment would appear to be negative; and this would be true even in irrigated regimes. This dramatizes the need for inclusion of consumption linkages in evaluating potential new technologies.

Weeder and transplanter. The second row in Table 3 shows the production and consumption effects of adopting and transplanters.

In contrast to the previous case, here both the direct effects and the portion of the indirect effects traceable to consumption effects are negative, and offset any increase in employment due to the indirect production effect. This is because weeders and transplanters lead to a decline in hired labor and because the landless have higher consumption propensities than other classes. However, if we look across columns, we find that the decline in employment associated with weeder and transplanter use diminishes with increasing level of irrigation. This happens as the decline in consumption effects become smaller while at the same time the increase in production effect becomes greater in more intensive irrigated regimes. Improved irrigated regimes with more income and a better distribution have far more consumption linkages than less sophicated irrigation systems.

Threshers and reapers. The third row in Table 3 shows the production and consumption linkages of employment effects in different water regimes from the adoption of threshers and reapers. It appears that the decline in net employment from this transformation is lower (or the increase is higher) than that occurring from a substitution of manual weeding and transplanting by weeders and transplanters. The decline in direct employment is also lower than the previous case, implying that employment in the rice sector remains relatively high.

Looking row-wise across the table it appears the combined employment effects of introducing power tiller/mini-tractors, weeders and transplanters, and reapers and threshers increase from simple to improved gravity to pump irrigation. The implications of the results in Table 3 are that in most cases micro-studies using farm employment data overestimate the net displacement of labor associated with mechanization. However, the indirect consumption effects may either reinforce the direct labor displacement effect or offset it, depending on the consumption patterns of the household classes who receive increased income. It is evident that the higher the level of mechanization, the larger is the gain from improved irrigation. Thus it is not mechanization, but low productivity caused by poor water control and inadequate inputs which are responsible for low employment. The indirect production effects increase with increasing mechanization for a given irrigation regime, indicating that production linkages play a greater role as mechanization proceeds.

Table 3. **Employment effect of mechanization corresponding to a 1000 ha change in paddy land from one sub-sector to another. Figures refer to the change in employment in man-years.**

Change examined in rice production	Rainfed					Gravity I			
	Direct		Indirect		Total	Direct		Indirect	
	First round	Equilibrium	Production	Consumption		First round	Equilibrium	Production	Consumption
Buffalo to power tiller/mini tractor. (Weeding, transplanting, reaping & threshing are done manually before and after change).	-46.8	121.1	2.5	18.0	94.8	-7.2	214.0	22.5	304.6
Hand weeding and transplanting to weeder & transplanter. (Land preparation, reaping & threshing are done mechanically both before and after change).	-	-	-	-	-	-23.7	-444.8	9.5	-40.9
Hand threshing and harvesting to thresher and reaper. (Land preparation is done mechanically; weeding and transplanting manually)	-	-	-	-	-	-24.8	-383.7	10.8	-15.5

Total	Gravity II					Pump				
	Direct		Indirect		Total	Direct		Indirect		Total
	First round	Equilibrium	Production	Consumption		First round	Equilibrium	Production	Consumption	
533.9	-36.0	322.6	46.6	1132.5	1465.7	-9.0	631.1	-79.2	883.7	1427.6
-499.9	-59.4	-417.2	28.9	-31.7	-479.4	-22.9	-89.6	14.89	290.3	192.69
-413.2	-31.5	-312.4	29.8	-50.2	-364.3	-27.7	-78.1	10.25	319.37	223.8

Income Effect of Mechanization

Table 4 indicates that meeting increased rice demand by moving 1000 hectares from buffalo to power tiller/mini-tractor leads to an increase in hired labor income which is much higher in irrigated regimes than in rainfed systems. Operator and landowner income are slightly higher in improved gravity than in pump irrigation. The income of hired labor increases progressively from simple to improved gravity and to pump irrigation.

Weeder, transplanter, reaper and thresher. Using weeders and transplanters rather than manual weeding and transplanting has the largest impact on hired labor income, even more than the change from manual threshing and harvesting to thresher and reaper. Operator farmers derive the greatest benefit from these transformations. As with employment, the decline in hired labor income diminishes with increasing irrigation. Also the increase in income for operator and landowner is generally higher in intensively irrigated regimes.

Hired labor gains more or loses less, relative to landowner and operators, the higher the level of irrigation. Looking row-wise across the table, we see that the combined effect of all machines on income of household classes becomes more favorable with intensive irrigated systems. On the other hand, increased productivity and labor intensity can offset the inequitable effects of mechanization.

Sector-wise Incremental Production

Table 5 shows sector-wise incremental production pattern for a selected set of simulations. Thus if the increased rice demand is met by increasing production from the modernized sector (subsector 10) involving improved gravity irrigation, buffalo, weeder, transplanter, reaper and thresher, gross output rises by Rp 3833.2 million. Both consumption and production linkages account for the incremental gross production. The following sectors show sharp increases in production: rice 81%, processed food 5%, textiles and footwear 3%, fertilizer 2%, chemicals 2%, manufacturing sector output 3%, construction and trade 3% of total incremental production simulation. The above pattern indicates that among other things, demand for food is likely to increase with modernization, even though the proportion of incremental income spent of food may decline as income increases. Inputs used in rice production (fertilizer, chemicals etc.) also show some increase in production.

Table 4. Income effect of mechanization corresponding to a 1000 ha change in paddy land from one sub-sector to another. Figures are changes in income (000 Rp).

Change examined in rice production	Rainfed			Gravity I			Gravity II			Pump		
	Hired Labor	Operator	Land Owner	Hired Labor	Operator	Land Owner	Land Labor	Operator	Land Owner	Hired Labor	Operator	Land Owner
Buffalo to power tiller/mini-tractor. (Weeding, transplanting & threshing done manually both before and after change)	3 874	4 618	5 451	51 218	62 204	62 888	85 072	92 424	88 777	108 917	69 081	93 240
Hand weeding and transplanting to weeder & transplanter. (Land preparation, reaping & threshing are done mechanically both before and after change)	-	-	-	-44 859	43 242	27 349	-40 848	67 596	52 816	-24 176	89 158	39 600
Hand threshing and harvesting to thresher and reaper. (Land preparation done mechanically; weeding and transplanting manually)	-	-	-	-18 541	26 252	25 204	-12 404	35 709	29 342	-12 493	52 223	49 000

Table 5. Gross output by sectors of the input-output table, 1980 (in million rupiahs and at producer's prices)[a]

	Sectors	Actual economy	Subsector 2[b]	Subsector 4[c]	Subsector 10[b]
1.	Rice	3130.4	3458	4783.1	6229.5
2.	Other farm food crops	1323.8	1323.8	1323.8	1323.8
3.	Other agricultural crops	981.2	981.2	981.2	981.2
4.	Livestock service and activities	21.9	21.9	21.9	21.9
5.	Fisheries & livestock products	840.9	840.9	840.9	840.9
6.	Forestry	359.8	359.8	359.8	359.8
7.	Mining and quarrying	2651.9	2651.9	2651.9	2651.9
8.	Processed foods	899.4	904.8	957.4	1674.6
9.	Sugar refining	136.9	136.9	136.9	136.9
10.	Textiles and footwear	604.7	608.8	646.5	734.7
11.	Wood and wood products	115.4	115.7	117.8	122.5
12.	Paper products and printing	121.2	121.2	121.2	121.2
13.	Fertilizer	35.0	36.0	58.3	107.8
14.	Chemicals	208.6	210.3	229.1	281.0
15.	Petroleum products	340.1	340.1	340.1	340.1
16.	Rubber products	43.5	43.7	46.3	52.0
17.	Other nonmetalic mineral products	95.8	95.9	97.3	100.2
18.	Cement	34.4	34.4	34.4	34.4
19.	Basic metal & fabricated metal products	232.4	232.4	232.4	232.4
20.	Agricultural machinery & repair	10.4	10.8	10.9	13.3
21.	Electrical machinery	111.5	109.5	116.2	126.8
22.	Transport machinery	717.5	717.7	738.9	785.2
23.	Other manufacturing industries	37.3	37.4	39.0	43.0
24.	Electricity, gas & water services	164.6	164.6	164.6	164.6
25.	Irrigation investment	94.7	94.7	94.7	94.7
26.	Other construction	1892.0	1892.4	1894.7	1899.0
27.	Trade	2138.1	2142.3	2165.2	2209.8
28.	Restaurants and hotels	584.8	585.1	586.9	590.4
29.	Transport and communication services	1227.1	1229.5	1241.6	1265.1
30.	Financial services	289.0	291.8	304.2	326.6
31.	Business and real estate services	454.5	454.7	456.1	458.9
32.	Social, public administration	1113.4	1113.5	1114.0	1115.0
33.	Recreation and household services	511.1	511.5	513.6	517.3
	Total	21523.3	21873.2	23420.9	25356.5
	Increase over actual economy	-	349.9	1897.6	3833.2

[a]Consumption is increased in each sub-sector of rice by an amount equal to the added production of rice arising from a 1000 ha increase in paddy cultivation.

[b]See Table 1.

Savings and Demand for Imports

Table 6 shows generation of savings and demand for imports under alternative mechanization strategies. From the table it appears that savings are higher in more intensive mechanized sectors in a given water regime. This happens because the increases in income for landowners are higher in these sectors. Imports are relatively higher in gravity II irrigation systems and in pump irrigation. The explanation for high imports in pump irrigation systems lies in the importation of mini-tractors; in gravity II irrigation, it lies in increased demand for consumer goods.

Comparison of Results with the Philippines

A similar study (Ahammed and Herdt, 1983b) was made for the Philippines. Although the nature of simulations were different in the two studies, some comparisons can be made. Although the linkages

Table 6. Generation of savings and demand for imports under alternative mechanization strategies[a].

Sub-sectors/systems[b]	Savings (000 Rp)	Imports (000 Rp)
1	2236.2	2659.7
2	2240.0	2663.1
3	2241.2	2663.8
4	2309.3	2721.4
5	2322.3	2729.3
6	2326.2	2732.4
7	2332.7	2737.1
8	2340.1	2741.1
9	2445.0	2829.3
10	2481.3	2851.4
11	2491.0	2861.7
12	2523.3	2886.5
13	2548.6	2905.2
14	2443.2	2834.4
15	2475.5	2858.2
16	2469.2	2735.6
17	2500.3	2744.6
18	2524.3	2751.3

[a] Consumption is increased in each sub-sector of rice by an amount equal to the added production of rice arising from a 1000 ha increase in paddy cultivation.

[b] As in Table 1.

are quite substantial in both countries, they are more important in Indonesia than in the Philippines. The reasons appear to be (1) higher land productivity in Indonesia than in the Philippines; (2) relatively fewer imports (or conversely more domestic production) in Indonesia than in the Philippines; (3) more labor-intensive production systems in both industry and agriculture in Indonesia; and (4) a more egalatarian land distribution in Indonesia.

CONCLUSION

Increasing food production in a modernizing agriculture has the potential for large growth-inducing linkages with other sectors of the economy. These linkages arise primarily because the new food-grain technology normally requires increased purchase of current and capital inputs, and more importantly because of the increase in demand for goods and services produced in other sectors of the economy. It is the increased marketing of food grains and consequent increased cash farm incomes which provide the important element in the linkages. The size of the linkages depend on the production structure, consumption behavior, nature of import substitution, and initial distribution of income.

Because of the nature of production and consumption linkages, sound planning requires knowledge of the distribution of benefits from food-grain technology, the consumption patterns accompanying increased incomes of various socio-economic classes, the capital-labor ratios in the industries experiencing increased demand, and the nature of other inhibitions to the expansion of these industries (such as fixity of supplies, import leakages etc.). Because of its sheer size, the rice sector offers particular opportunity for a net increase in employment through changes in consumption expenditures arising from substitution among alternative production patterns. Our exploration of these factors suggests that consumption linkages are higher for sectors giving relatively more income to hired labor. Thus in the case of stimulus to growth arising from increased food-grain production, long run equity and production considerations may be highly complementary.

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