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New Rice Technology and Income Distribution*

—— A Perspective from Villages in Java ——

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1. Introduction

The development and diffusion of modern rice and wheat varieties, often heralded as the "green revolution", have had a profound impact on the economies of tropics. The new technology has often been blamed on the ground that it promotes inequitable income distribution. The arguments run as follows: The new technology tends to be monopolized by large commercial farmers who have better access to new information and better financial capacity; modern varieties can profitably use higher applications of modern inputs such as fertilizers and chemicals; adoption of the modern varieties is difficult for small subsistence farmers who have little financial capacity to purchase these inputs; a large profit resulting from its adoption by a few large farmers would stimulate them to enlarge their operational holdings by consolidating the farms of small nonadopters through purchase or tenant eviction; as a result, polarization of rural communities into large commercial farmers and landless proletariat would be promoted[1].

Indeed, such arguments are not groundless. It is not difficult to find cases in which poverty and inequality increased side by side with the diffusion of modern varieties. The point of controversy is whether the new technology is, in fact, a cause of the growing inequality or they are merely concurrent events or related each other in a

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1) Such arguments were mentioned by Falcon [4], Johnston and Cownie [8], Palmer [10] and Wharton [12]. More radical views were expressed by Cleaver [2], Frankel [5] and Griffin [6].

different loop other than commonly conceived.

In order to shed light on this problem, we attempted a comparative analysis of two villages located in a same geographic district in Java—one characterized by technological stagnation and another by significant technological progress. By comparing the two cases, we try to single out the effects of technological change. Java serves as a social observatory uniquely suited for the problem concerned, because rural poverty is especially serious with its extremely high population density and because it has long been feared that the population pressure together with modernization forces such as new technology are destroying traditional village institutions and are resulting in the greater misery of the poor[2].

2. Study Sites and Data Collection

Two villages chosen for the comparative analysis are located in the Regency (*kabupaten*) of Subang in West Java, adjacent to the north of the Bandung Regency and about 120 km east of Jakarta (Fig. 1)[3].

One village is located at the foot of mountains in the southern part of the Subang Regency—henceforth we call it the "South Village." A major area of the village consisted of rice terraces waving in gradual undulation. Another village—henceforth called the "North Village" is located in about 20 km north of the South Village. Unlike the South Village characterized by an undulated topography, the North Village belongs to a completely flat coastal plain along Java Sea.

Those two villages are chosen among those covered by the Rice Intensification Survey (*Intensifikasi Padi Sawah*) which was conducted by the Agro-Economic Survey of Indonesia for 1968–72. The data collected from this previous survey provide the benchmark information with which historical changes can be ascertained. We conducted a complete enumeration survey to each village in order to collect both economic and institutional data[4]. The survey periods were January 1979 for the South Village and November-December 1979 for the North Village. Henceforth, the analysis is based on the 1968–71 data taken from the Rice Intensification Survey, and the 1978 data for the South Village and 1978/79 data for the North Village from our surveys.

3. Population Pressure and Agrarian Structure

As is common to rural Java, both of the two villages are characterized by very unfavorable land/man ratios. In South Village, as many as 419 persons staked out their subsistence primarily from only about 25 ha of wet ricefield (*sawah*). The land/man ratio was somewhat higher for the North Village. Yet, per-capita land endowments were below 0.1ha for both cases (Table 1)[5].

2) Such perspective was originally developed by Boeke [1], followed by many scholars in different viewpoints and approaches. For a typical expression in recent years, see Collier, *et. al.* [3].

3) The community called "village" in this study is *kampung*. *Kampung* might be more appropriately called "hamet" in which houses are clustered together to form an indigenous community. The official administrative unit in rural areas of Java is *desa* which includes a few *kampungs*.

4) For detail on the institutional aspect of the South Village, see Kikuchi, *et. al.* [7].

5) In addition to wet ricefields, the South Village had 3 ha of land used for home gardens and fish ponds, and the North Village had 8 ha.

Although the population density was higher for the South Village, the rate of population growth seems to have been much faster for the North Village. Data on the number of children per mother suggests that the natural rate of population growth in the South Village decelerated from about 3% per year to 1% during the past 40 years, while there is no sign for a significant inflow of migrants (Table 2).

Although we failed to obtain reliable data for the old-age brackets, the comparison of average numbers of children per mother in Table 2 suggests that the natural rate of population growth was much faster in the North Village than in the South Village[6]. Moreover, a large number of migrants flowed into this village. According to the memory of old villagers, the total number of households in the North Village had been about 40 in 1940, which increased to 191 at the time of our survey. Assuming no change in average family size, the rate of population growth for the past 4 decades have been as high as 4% per year.

Agrarian structures were also different between the South and and the North Villages. As shown in Table 1, the South Village was a typical peasant community with three

Table 1. Comparison of land area, population and number of households between the South and the North Villages, in the Regency of Subang, West Java, Indonesia

	South Village (1978)	North Village (1979)
Total rice land (ha)	24.7	66.4
Total population (no.)	419	774
Total number of households	110 (100)[a]	191 (100)[a]
Farm operators	83 (75)	74 (39)
Landless laborers	27 (25)	117 (61)
Rice land per capita (ha)	0.06	0.09
Rice land per household (ha)	0.22	0.35
Rice land per farmer household (ha)	0.30	0.90

a) Percentages in the total number of households are in parentheses.

Table 2. Average numbers of surviving children per mother by mothers' age and the estimates of the natural rates of population growth in the South and North Villages, in the Regency of Subang, West Java, Indonesia

Mothers' age	South Village		North Village	
	Children per mother (n) No.	Population growth rate[a] (r) %/year	Children per mother (n) No.	Population growth rate[a] (r) %/year
80 years and above	4.80	3.0	n. a.	—
60–79	3.93	2.3	n. a.	—
50–69	3.49	1.9	n. a.	—
40–49	2.71	1.0	3.25	1.6
(36–45)	(2.48)	(0.7)	(3.16)	(1.5)
30–39	1.95	—	2.57	—
20–29	0.84	—	1.80	—

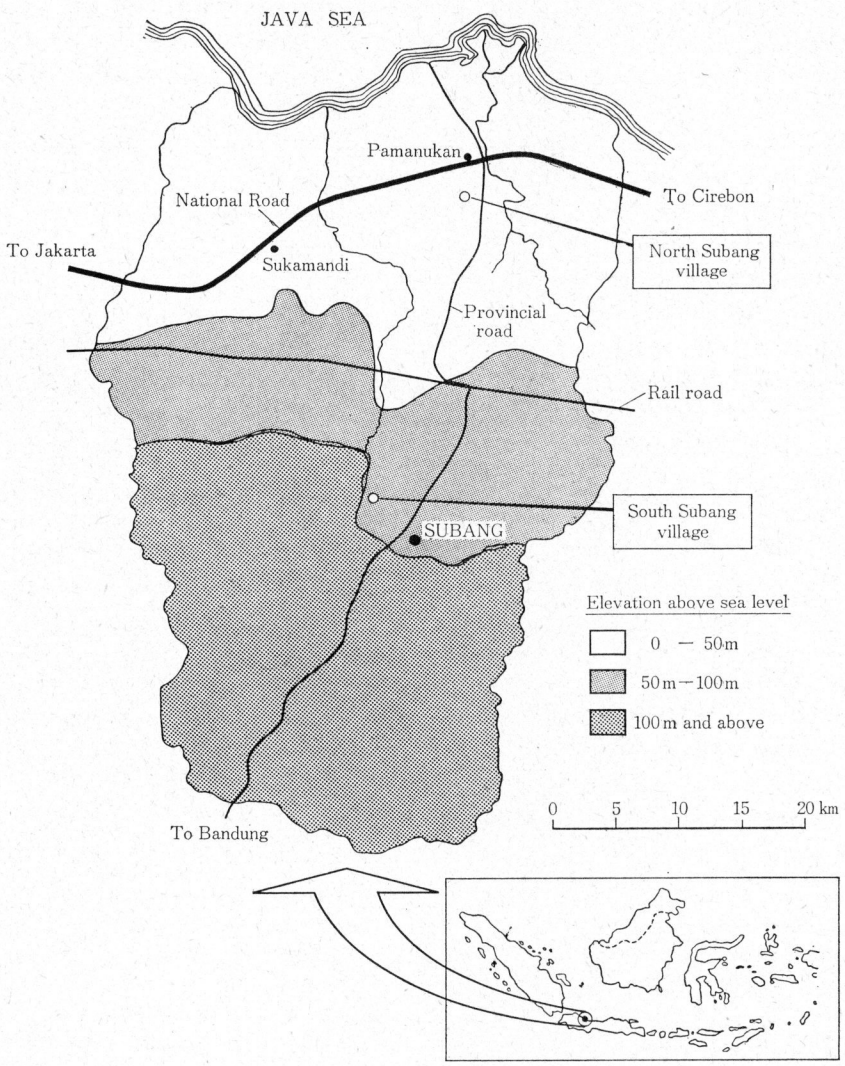
a) Calculated by the formula: $n=2(1+r)^{30}$, assuming 30 years for the period of mothers' reproductive capacity.

Table 3. Distribution of farms by tenure status in the South and the North Villages, in the Regency of Subang, West Java, Indonesia

	South Village (1978)		North Village (1979)	
	Number of farms	Rice area	Number of farms	Rice area
Owner operator	81	77	46	43
Owner/tenant	16	21	17	30
Tenant operator	3	2	37	27
Total	100	100	100	100

6) Due to the limitation of time and resources, we were unable to trace out children moved out from parents' households in the North Village as we did in the South Village. Thus, the data for mothers in the old age brackets are subject to serious underestimation. In our judgement, only the

Figure 1. Map of the Regency of Subang, West Java, Indonesia



quarters of households being small farm operators and only one quarter being landless laborers. Whereas, only about 40% of households in the North Village was farm operators and 60% landless laborers. The incidence of tenancy was significantly higher in the North Village than in the South Village. Almost all tenants were sharecroppers under the contract of output and cost-sharing of 50: 50.

Such differences in the agrarian structure as well as in the demographic pattern can be explained by different histories of settlement. The South Village is an old village for which no one knew when its settlement had begun. In contrast, the North Village

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data for younger mothers as shown in Table 2 are meaningful, even though those data are still subject to underestimation to some extent.

was settled recently, only after 1920; the settlement begun late because it was more difficult to build a gravity irrigation system at a local level in the flat coastal plain than in the mountain-locked areas with decent undulation such as the South Village.

Initial settlers in the North Village opened no man's land and practiced very extensive farming under a rainfed condition. Because the rice yield in the rainfed condition was very low, the operational holding of about 2 ha was required for a family's subsistence. Thus, relatively large-scale holdings in the Javanese standard had been established. Rice yields in this village were raised significantly after the local irrigation system was built to irrigate the village fields for wet season.

Corresponding to the intensification of rice farming due to the irrigation development, labor demand increased and a large number of migrants flowed into this village. Those new migrants settled in this village as landless laborers or sharecroppers. The same process was repeated after the extension of the Jatiluhur System, the largest irrigation system in Java, that enabled irrigation for both wet and dry seasons. The class differentiations between relatively large farmers and a large number of landless workers and between landowners and tenants were thus developed through the waves of migration.

The Jatiluhur Irrigation System had a dramatic impact on the economy of the North Village. Major laterals had been built by 1968 but it was not until 1972 that secondary and tertiary laterals were completed and that the whole area of the village became amenable to rice double cropping. According to the Rice Intensification Survey, double cropping was practiced in about a half of the *sawah* area in 1968–71. In 1979 when our survey was conducted, the whole area was double cropped (Table 4).

Table 4. Changes in multiple cropping, MV adoption and rice yield per ha in the South and the North Villages, in the Regency of Subang, 1968–71 to 1978/79

	South Village			North Village		
	1968–71[a]	1978[b]	%Change[d]	1968–71	1978[c]	%Change[d]
Multiple cropping ratio[e]	1.9	1.9	0	1.5	2.0	33
Ratio of MV adopters (%)	11	14	3	7	100	73
Rice yield (kg/ha):						
Per ha of crop area	2.6	2.9	12	2.4	3.5	46
Per ha of rice field area	4.9	5.5	12	3.6	6.7	86

a) Averages of dry and wet seasons.
b) 1978 dry season.
c) Averages of 1978/79 wet season and 1979 dry season.
d) 1978 or 1979 figure minus 1968–71 figure divided by 1968–71 figures, except for the ratio of MV adopters which is simply 1978 or 1979 figure minus 1968–71 figure.
e) Total crop area divided by total rice field area.

The introduction of the double cropping system was facilitated by the diffusion of modern semi-dwarf varieties (MV) which have early maturing and nonphotosensitive characteristics. According to the Rice Intensification Survey, 7% of farmers planted MV in 1968–71. The ratio went up to 100% in 1978/79. There was no difference in the MV adoption rate among farm-size classes and among tenure classes. The MV's commonly used in 1979 were *IR 26, IR 36, IR 38* and *Asahan* developed by the Central Agricultural Experiment Station at Sukamandi nearby to the North Village (Fig. 1).

With the diffusion of MV accompanied by the increased application of fertilizers, the average yield per ha of rice crop area increased from 2.4 tons 1968–71 to. 3.5 tons

in 1978/79. Considering the increase in the multiple cropping ratio from 1.5 to 2.0, the average rice output per ha of *sawah* land per year should have increased more than 80% during past decade.

In contrast to the dynamic changes in the North Village, the economy of the South Village was largely stagnant. The local irrigation system had been well developed ever since people's memory. There was no significant improvement in the system as well as no expansion in cultivated area since before World War II. Growing population pressure resulted in the increased fragmentation of landholdings through inheritance. The number of near-landless peasants increased even though the ratio of pure landless laborers was not so large as compared with that of the North Village (Table 1).

Same as for the North Village, MVs were introduced in the late 1960's under the *Bimas* Program—a nationwide program of rice production intensification based on a package of modern inputs, credit and extension. However, because they were highly susceptible to insect (brown planthopper) and pest (tungro virus disease), many farmers who had tried them shifted back to traditional varieties. At the time of our survey, only 14% of farmers were still adopting MV and the rest used traditional varieties, although as much as 83% of farmers had once tried MV. As a result, the rate of increase in the average rice yield per ha of crop area in this village was much slower than in the North Village (Table 4).

It appears that the population pressure on limited land resources under a constant technology had reached a saturation point a few decades ago such that the villagers were compelled to suppress the birth of children, as reflected in the data in Table 2. It was in 1975 when the government program of birth control was first introduced. However, the birth rate began to decline much earlier. They say that many wives had practiced abortion by indigenous methods which were often harmful to their health.

In short, the economy of the South Village approximates the world of classical economists like Malthus [9] and Ricardo [11], in which population pressure on a fixed land resource under constant technology results in a stationary state of no population growth with the minimum subsistence level of living.

4. Labor Employment and Wages

The different patterns of technological progress (defined here broadly as the shift of production function due to both irrigation improvement and MV diffusion) between the North and the South Villages were reflected in sharp differences in the changes in rice production inputs and input prices for the past decade (Tables 5 and 6).

In the South Village where technology was stagnant, the input of fertilizers per ha of crop area increased only at a rate lower than the rate of decline in the real price of fertilizers. Whereas, in the North Village, in which the fertilizer-responsive MVs were widely adopted, the per-hectare input of fertilizers increased at a rate 6 times faster than the rate of decline in the price of fertilizers.

Dramatic contrasts can also be observed in the changes in the inputs of labor and animal power in relation to their price changes. In the South Village, an increase in labor input was associated with a decline in the real wage rate. Meanwhile, the real rental rate of draft animals (carabao and cattle) increased with the result of a sharp

decline in the use of animal power. Underlying this process was the substitution of hand hoeing for animal plowing and harrowing due to the decline in the labor wage rates relative to the animal rental costs. It is clear that the population pressure on land under a stagnant technology resulted in a decline in the value of human labor relative to the values of both capital and food.

In contrast, in the North Village, an increase in labor input was associated with a significant increase in the real wage rate. The average labor input per ha of rice crop area did not increase so much. However, the labor input per ha of ricefield area increased more than 40% per decade, owing to the increase in the multiple cropping ratio (figures in parentheses in the final column of Table 5). At the same time, the use of animal power increased even more rapidly than the use of human labor, despite a rapid rise in the real cost of animal rental. It is clearly shown that the increase in labor demand due to technological progress outpaced the increase in labor supply due to population growth with the result of rising wages despite the effort to substitute capital (animal power) for human labor.

Table 5. Changes in inputs per hectare of rice crop area and input price for rice production in the South Village, 1968–71 to 1978

	1968–71[a]	1978[b]	% Change from 1868–71 to 1978
Inputs:			
Fertilizer (kg/ha)	191	229	20
Labor (hours/ha):			
Land preparation	420	494	18
Total (preharvest)	736	928	26
Carabao & cattle for land preparation (days/ha)	16.4	9.2	−44
Real input prices (in paddy)[c]:			
Fertilizer (kg/kg)	1.5	1.1	−27
Labor wage (kg/day)	9.5	8.5	−11
Carabao rental (kg/day)	6.2	9.5	53

a) Averages for wet and dry seasons.
b) Wet season.
c) Nominal price divided by paddy price.
d) Wage for land preparation, assuming 8 hours per day. Include meals.

Table 6. Changes in inputs per hectare of rice crop area and input prices for rice production in the North Village, 1968–71 to 1978/79

	1968–71[a]	1978/79[b]	% Change from 1968–71 to 1978/79
Inputs:			
Fertilizer (kg/ha)[c]	75	209	179
Labor (hours/ha):			
Land preparation	219	233	6 (42)[g]
Total (preharvest)	638	701	10 (46)[g]
Carabao & cattle for land preparation (days/ha)[d]	9.6	13.2	38 (83)[g]
Real input prices (in paddy)[e]:			
Fertilizer (kg/kg)	1.5	1.0	−33
Labor wage (kg/day)[f]	7.9	11.5	46
Carabao rental (kg/day)[d]	8.8	14.1	60

a) Averages for wet and dry seasons.
b) Averages for 1978/79 wet season and 1979 dry season.
c) Urea and TPS.
d) Data for wet season only.
e) Nominal price divided by paddy price.
f) Wage for land preparation, assuming 8 hours per day. Include meals.
g) Outside of parentheses are the rates of increase in labor input per ha of cropped area. Inside of parentheses are the rates of increase per ha of paddy field area.

5. Changes in Income Distribution

How were the major differences in technological change reflected in different patterns of income distribution between the South and North Villages? Data are not available to

identify overtime changes in the size distribution of income. Therefore, we will try to make inference based on changes in the shares of income from rice production.

South Village Case

Changes in the average factor shares of rice output per ha of crop areas in the South Village from 1968–71 to 1978 were estimated (Table 7); factor payments are expressed in paddy terms by multiplying factor inputs by factor-product price ratios. During the period the average yield per hectare increased by a little more than 10%. Both the payment to hired labor and the imputed cost of family labor increased very slightly, less than 5%. Operator's surplus (residual) recorded a major increase in the case of owner farmers. In the case of tenant farmers, operators' surplus was almost zero and land rent paid to landlords was equivalent to owner farmers' surplus. Such results show clearly that the operators' surplus of owner farmers consisted mainly of the return to their land. Thus, the major gain in owner farmers' surplus implies the increase in the economic rent of land. Altogether, the relative share of labor declined and the relative share of land increased.

Table 7. Changes in factor payments and factor shares in rice production per ha of crop area in the South Subang Village, 1968–71 to 1978

	Factor payment (kg/ha)			Factor share (%)		
	1968–71[a]	1978[b]		1968–71	1978	
	Owner	Owner[c]	Tenant[d]	Owner	Owner	Tenant
Rice output	2,600	2,942	3,080	100.0	100.0	100.0
Factor payment[e]:						
Current input[f]	380	328	356	14.6	11.1	11.6
Capital[g]	101	90	41	3.9	3.9	1.3
Labor	1,257	1,301	1,341	48.4	44.2	43.5
(Family)	(427)[h]	(438)	(476)	(16.4)	(14.9)	(15.4)
(Hired)	(830)[h]	(863)	(865)	(31.9)	(29.3)	(28.1)
Land	0	0	1,262	0	0	41.0
Operator's surplus	862	1,223	80	33.1	41.6	2.6

a) Averages for wet and dry seasons.
b) 1978 dry season.
c) Averages of 74 owner farmers cultivating 20.4 ha.
d) Averages of tenant operators cultivating 1.8 ha.
e) Factor payments converted to paddy equivalents by the factor-output price ratios.
f) Seeds, fertilizers, chemicals and irrigation fee.
g) Animal rental for land preparation.
h) Assume the same composition of family and hired labor as for 1978.

What do such estimates imply on the income distribution between farmers and landless laborers? Table 8 attempts to show how the income (value added) from rice production per ha was distributed between farmers and hired laborers. Farmers' income consists of operator's surplus and the returns to family labor and capital. Laborers' income consists of wage earnings from hired farm works. Farmers' total income in paddy terms increased from 1968–71 to 1978 by 25%, whereas laborers' income increased by only 4%. Employment of hired labor itself increased due to more intensive crop cares and substitution of human labor for animal power. But the increase was compensated for, to a large extent, by the decline in the wage rate. On the other hand, farmers' income increased significantly, primarily due to the increase in the return to land captured in the form of operator's surplus. As a result, farmers' income share increased and laborer's share declined. The data clearly suggest that the income distribution became more skewed.

It is most probable that the size distribution of income between farmers and laborers became more skewed than the data in Table 8 show. From 1968–71 to 1978, the number of landless and near-landless households increased faster than the number of farmers.

Therefore, the share of income per landless household should have declined by a greater extent than the share of income per hectare. It is highly likely that per-household or per-capita income from rice production for landless and near landless households declined in absolute terms, even though the rice income per hectare increased slightly.

North Village Case

Changes in the average factor shares of rice output per ha in the North Subang Village from 1969–71 to 1978/79 were estimated in Table 9. During the period, the average yield per ha for wet and dry seasons increased by 40%. Despite such rapid increase in output, the relative share of labor stayed almost constant. Meanwhile, the shares of both current inputs and capital increased. As a result, the share of operators' surplus declined for the case of owner farmers.

In the case of tenant farmers, operators' surplus was almost zero and land rent paid to landlords was equivalent to owner farmers' surplus, implying that the operator's surplus of owner farmers consisted mainly of the return to their land. Thus, the results in Table 9 are consistent with the hypoth-

Table 8. Changes in shares of income from rice production per ha of crop area in the South Subang Village, 1968–71 to 1978[a]

	Income in paddy (kg/ha)		Income share (%)	
	1968–71	1978	1968–71	1978
Value added[b]	2,220	2,614	100.0	100.0
Farmer:				
Family labor	427	438	19.2	16.8
Capital	101	90	4.6	3.4
Operator's surplus	862	1,223	38.8	46.8
Total	*1,390*	*1,751*	*62.6*	*67.0*
Hired laborer	*830*	*863*	*37.4*	*33.0*

a) Data rearranged from Table 7 for owner-operated farms.
b) Output value minus current input cost.

Table 9. Changes in factor payments and factor shares in rice production per ha of crop area in the North Subang Village, 1968–71 to 1978/79

	Factor payment (kg/ha)			Factor share (%)		
	1968–71[a]	1978/79[b]		1968–71[a]	1978/79[b]	
	Owner	Owner	Tenant[c]	Owner	Owner	Tenant[c]
Rice output	2,342	3,237	3,272	100.0	100.0	100.0
Factor payment[d]:						
Current input[e]	152	296	280	6.5	9.1	8.5
Capital[f]	47	151	154	2.0	4.7	4.7
Labor	947	1,343	1,295	40.4	41.5	39.6
(Family)	(117)	(273)	(357)	(5.0)	(8.5)	(10.9)
(Hired)	(830)	(1,070)	(938)	(35.4)	(33.0)	(28.7)
Land	0	0	1,495	0	0	45.7
Operator's surplus	1,196	1,447	48	51.1	44.7	1.5

a) Averages for wet and dry seasons.
b) Averages of 1978/79 wet season and 1979 dry season.
c) Data for share tenants.
d) Factor payments converted to paddy equivalents by the factor-product price ratios.
e) Seeds, fertilizers, chemicals and irrigation fee.
f) Animal and tractor rental for land preparation.

Table 10. Changes in shares of income from rice production per ha of crop area in the North Subang Village, 1978/79[a]

	Income in paddy (kg/ha)		Income share (%)	
	1968–71	1978/79	1968–71	1978/79
Value added[b]	2,190	2,940	100.0	100.0
Farmer:				
Family labor	117	273	5.3	9.3
Capital	47	151	2.1	5.1
Operator's surplus	1,196	1,446	54.6	49.2
Total	*1,360*	*1,870*	*62.1*	*63.6*
Hired laborer	*830*	*1,070*	*37.9*	*36.4*

a) Data rearranged from Table 9 for owner-operated farms.
b) Output value minus current input cost.

esis that the technological progress in this village was biased toward a land-saving and capital-using direction and was more or less neutral with respect to the use of labor. Such results for the North Village represent a sharp contrast to the case of the South Village where the share of land increased sharply at the expense of the share of labor (Table 7).

The data in Table 9 are rearranged in Table 10 to show how the income (value added) from rice production per ha was distributed between farmers and hired laborers. Both farmers and laborers recorded significant gains in their absolute incomes, while their relative shares remained largely unchanged. Again, such results contrast with the case of the South Village where the income of laborers did not show a significant increase and their relative income share declined (Table 8).

6. Conclusion

The comparative analysis of two villages in West Java sheds a light on the net effect of technological change on income distribution.

In the South Village, population pressure had long before reached its limit and the population growth decelerated but labor force continued to increase; technology was stagnant because modern varieties effective in the environmental condition of this specific location were not available; fertilizer application increased not because of new technology but because of low fertilizer prices subsidized under the *BIMAS* Program. Gains in rice yields were not so significant; the increase in labor force against limited land resources under stagnant technology resulted in the decrease in the economic return to labor; the real wage rate for land preparation declined, inducing the substitution of hand hoeing to animal plowing and; labor's income share declined relative to land's share.

The dismal process of growing poverty and inequality of the South Village approximates the classical model of Ricardo [11]. As the growth of population presses hard on limited land resources under constant technology, cultivation frontiers are expanded to more marginal land and greater amounts of labor applied per unit of cultivated land; the cost of food production increases and food prices rise; in the long end, laborers' income will be lowered to a subsistence minimum barely sufficient to maintain stationary population and all the surpluses will be captured by landlords in the form of increased land rent. This was exactly what occured in this village.

In the North Village, the Ricardian force of population pressure was counteracted by technological progress; the improvement in irrigation system together with the diffusion of MV not only increased the average yield per ha of rice crop area but also contributed to a dramatic expansion in the area under double cropping; labor demand increased and the real wage rate rose significantly, despite the large inflow of migrant laborers and farmers' effort to substitute animal power for human labor; the relative income share of labor rose relative to that of land and the income of laborers increased absolutely if not relatively.

The comparative analysis of two village cases have shown clearly that contrary to a popular belief, growing poverty and inequality will be an inexorable fate of Asian village economies if the efforts to generate technological progress, together with the efforts for agrarian reform and other rural development programs remain insufficient to

overcome the decreasing return to labor due to the growing population pressure on land.

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