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Poor Rural Households, Technical Change, and Income Distribution in Developing Countries: Insights from Asia

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SUMMARY AND CONCLUSIONS

Technological Change in Rice Production in Asia

The widely held conception of changing rice technology in Asia is that of the "Green Revolution," which is associated with the introduction of higher yielding semi-dwarf rice varieties. These modern varieties (MV) were first released for commercial production by the International Rice Research Institute (IRRI) in 1965/6, and have since been widely adopted throughout Asia. The complementary adoption of MV and inorganic fertilizers, plus improved water control, constitute the central aspects of technological change in rice farming. The benefits of the adoption of these technologies accrue in two ways: First, they provide for significantly higher yields per crop. But in many areas it is of equal or even greater importance that they have permitted multiple cropping--an increase in the number of successive crops grown per hectare--in some cases as many as five crops in two years. To achieve high levels of cropping intensity, improved water management is essential, but the availability of faster maturing modern varieties also plays an important role, as does the adoption of improved systems of transplanting seedlings.

Second, there have also been significant changes in the adoption of other modern inputs, such as tractors, mechanical threshers, pumpsets, herbicides, and insecticides. Since these inputs often substitute for traditional factors such as animal power--but most importantly, labor--their adoption gives rise to especially significant policy issues relating to the distribution of output between labor and other factors of production. It is clear that the reasons for adopting these other technologies are not to be found solely in the technical and economic conditions brought about by the introduction of MV. The data in table 1 indicate that there was a significant level of adoption of some "modern" technologies prior to the introduction of MV. Seventy-five percent of the sampled Indonesian farmers, 62 percent of those in Pakistan, and a sizable number of those in the other study areas had employed inorganic fertilizer prior to 1966. Tractors were relatively common in Pakistan and the Philippines before 1966, and mechanical threshers and herbicides were employed on more than 30 percent of Philippine farms; insecticides were widely used in all the areas except Malaysia and Pakistan. Evidence that technologies other than fertilizer, and possibly insecticide, are not necessarily complementary with MV is provided by the fact that in several of the countries shown in table 1, their use was negligible or significantly lower than the rate of adoption of MV.

Using the IRRI data in table 2, it is interesting to observe the influence of farm size on the technology adopted. As can be seen, there is comparatively little difference between the three size classes in their rate of adoption of the complementary technologies--MV, fertilizer, and insecticide. In fact, the largest farms appear to have a marginally lower rate of adoption of these technologies than the smallest farms. In con-

TABLE 1--Cumulative Proportion (%) of Farmers Who had Used Modern Technology in 31 Villages in Selected Areas of Asia, by Technology Type, by Country

	1900–1960	1961–1966	1967	1968	1969	1970	1971	1972	Percentage Using in 1972
Modern Varieties of Rice[f]									
India	0	0[d]	27	43	77	93	96	96	()[c]
Indonesia	0	0	28	64	83	88	90	90	()[c]
Malaysia[a]	0	0[e]	--	--	--	--	100	100	()[c]
Pakistan	0	0	0	11	21	38	100	100	()[c]
Philippines	0	0	36	71	91	99	100	100	()[c]
Thailand	0	0	0	0	0	41	92	82	()[c]
Fertilizer[a]									
India	6	41	60	70	91	97	98	100	99 (100)[b]
Indonesia	32	75	81	94	99	99	99	99	99 (96)
Pakistan	27	62	65	72	79	80	81	81	76 ()[c]
Philippines	15	33	51	67	77	80	83	84	72 (76)
Thailand	2	20	27	38	50	61	76	82	69 (82)
Tractors									
India	0	9	11	13	20	22	27	27	26
Indonesia	0	0	1	3	5	14	15	15	2
Malaysia[a]	--	--	--	--	--	--	--	96	96
Pakistan	3	46	57	67	72	73	73	73	73
Philippines	10	24	37	46	57	61	61	61	58
Thailand	0	5	6	9	15	22	33	33	25
Mechanical Threshers[a]									
India	0	7	8	9	9	9	9	9	9
Indonesia	0	0	0	0	0	0	0	0	0
Pakistan	0	0	0	0	0	0	0	0	0
Philippines	19	27	38	50	62	65	65	66	63
Thailand	1	6	11	27	38	45	55	55	44
Insecticide									
India	3	31	48	63	80	89	91	91	88
Indonesia	31	68	74	92	93	96	96	96	92
Malaysia[a]	--	--	--	--	--	--	--	45	45
Pakistan	4	9	9	25	42	55	58	58	58
Philippines	16	43	59	75	89	95	97	97	97
Thailand	5	32	39	42	50	56	76	76	71
Herbicide									
India	--	1	1	2	2	2	2	2	0
Indonesia	--	0	0	0	0	0	0	0	0
Malaysia[a]	--	--	--	--	--	--	--	8	6
Pakistan	--	0	0	0	0	0	0	0	0
Philippines	--	32	45	51	67	71	72	76	65
Thailand	--	4	6	6	7	10	10	10	8

Source: IRRI (1978a), pp. 16, 99, 100.

Notes: [a]Data missing for Malaysia for all or part of the period.
[b]The figures in parentheses are for the dry season, the others for the wet season.
[c]Not available.
[d]Modern rice varieties were introduced in India in 1965/6.
[e]Modern rice varieties were introduced in Malaysia in 1965.
[f]The data on adoption of modern rice varieties is for 32 villages. Data for Zarain in India was omitted in calculating the other statistics.

TABLE 2--Cumulative Rate of Adoption of Some Improved Rice Culture Practices by Farmers in Selected Areas in Asia, 1971/72

Practice, farm size	1900-1960	1961-1966	1967	1968	1969	1970	1971	1972
	Cumulative rate (%) of adoption							
				MV				
1 ha or less	0	13	35	69	85	89	93	93
1.1 to 3.0	0	9	27	56	89	98	99	99
over 3 ha	0	7	19	34	49	68	92	92
				Fertilizer				
1 ha or less	23	55	73	92	96	97	98	98
1.1 to 3.0	10	34	48	64	78	83	86	88
over 3 ha	14	50	61	73	81	86	90	91
				Insecticide				
1 ha or less	23	49	64	84	89	92	93	93
1.1 to 3.0	12	39	53	67	87	94	95	95
over 3 ha	6	32	45	52	62	70	83	83
				Herbicide				
1 ha or less	0	0	0	0	0	0	0	0
1.1 to 3.0	6	13	16	21	29	31	32	32
over 3 ha	3	27	39	48	56	63	71	71
				Tractor				
1 ha or less	0	18	19	20	21	25	25	25
1.1 to 3.0	6	13	16	21	29	31	32	32
over 3 ha	3	27	39	48	56	63	71	71
				Mechanical thresher				
1 ha or less	0	0	1	1	1	1	1	1
1.1 to 3.0	8	12	15	22	31	32	33	33
over 3 ha	9	21	30	35	39	41	44	44

Source: IRRI (1978a), p. 91.

trast, the largest farms show a markedly higher rate of adoption of mechanical technology (tractors and threshers) and herbicides. This confirms that these particular inputs are not indispensable complements to MV, fertilizer, and irrigation, and being substitutes for labor, they have no significant place in the production systems of labor-abundant small farms.

Further justification of this last assertion is provided by the results of Hart's (1978) Indonesian study. The land farmed by all farm-size classes in the study village was virtually homogeneous in quality, yet Hart's data, presented in table 3, indicate that the smallest farms apply 76 percent more labor per hectare than the largest farms, and obtain approximately 60 percent higher yields. This is consistent with the results from other Asian sites, which show that small farmers apply their abundant labor intensively in order to maximize output per hectare, and are receptive to technology which permits them to achieve higher yields in this manner.

TABLE 3—Labor Input[a] and Yields by Farm Size in Rice Production Preharvest Activities, Village A, Central Java, Indonesia (Wet Season in 1975-76)

		A >1.0	B .50-.99	C .30-.49	D .19-.29	E <.19
Average area (hectares)		3.147	0.676	0.377	0.271	0.118
Absolute labor input (hours)						
Female:	Family	40	45	54	87	65
	Hired	1209	211	109	72	27
	Total	1249	256	163	159	92
Male:	Family	1277	88	135	119	68
	Hired	1335	210	84	49	17
	Total	1462	298	219	168	85
Total absolute labor input		2711	554	382	327	177
Labor input per hectare (hours)						
Female:	Family	20	66	143	354	455
	Hired	360	306	306	266	233
	Total	380	372	449	620	688
Male:	Family	70	133	383	456	619
	Hired	374	296	223	180	147
	Total	444	429	606	636	766
Total labor input per hectare		824	801	1055	1256	1454
Yield per hectare (tons of wet paddy)		1.965	2.318	2.220	2.546	3.123
No. of observations		6	13	13	11	17

Source: Hart (1978), p. 143.

[a]A female labor day (transplanting and weeding) is between four and five hours, whereas the average male labor day is seven hours. Labor data exclude supervisory work and travelling time. They also exclude activities such as protecting the crop from birds in the period before the harvest, and preparing food for laborers.

Constraints to the Adoption of New Technology

Yields achieved on experiment station test plots are considerably higher than those realized in farmers' fields. It may be unrealistic to express test plot performance as a target; however, it is important to consider factors which bear on the gap between what is technically feasible and farm level performance. Quantification of components of the yield gap, and ascertaining a target which farmers might realistically be expected to reach, is extremely difficult.

While it is easy to understand the frustration of national planners attempting to increase rice production, it seems that expectations are frequently pitched too high. Most research to date has concentrated on improving rice technology for areas with good water control, while less progress has been made for lowland rainfed, upland, or deep water rice. Thus, only in those countries where irrigated rice land represents a substantial proportion of the total rice-growing area can large increases in yield and input use be expected.

Even in the well-irrigated areas to which the new technology is adapted, it appears that there may be a serious danger of over-estimating potential. This is suggested by the results of an interesting research program conducted by IRRI in South and Southeast Asian countries (IRRI, 1975; Herdt, 1976). This research was conducted in irrigated areas where all farmers employed MV, where rice was the main, or only crop, and where husbandry practices could be considered progressive. The research was carried out in farmers' fields, and was designed (1) to test the contributions to yields attributable to the use of fertilizer, insecticide, and weed control; (2) to estimate the economic optimum use of these inputs; and (3) through surveys accompanying the field experiments, to determine the reasons why farmers' use of inputs was below the economic optimum. It was found that high input applications on farmers' fields led to lower yields than those of experiment stations, due to differences in environment and to elements of nontransferability of the technology.

There were significant differences depending on the season. In the wet season, only comparatively modest increases could be made by increasing the levels of the three inputs, the average potential yield gain being 0.9 metric tons per hectare, with a range from 0.1 to 2.0 (see table 4). In the dry season, larger potential yield gains were possible, with an average of 1.5 metric tons per hectare and a range of 0.4 to 2.2 (table 5). It should be noted that due to a peculiarity in the definitions used, the maximum attainable dry season yields at several centers were significantly higher than the "potential" levels. Nevertheless, these maximum yields are less dramatic than experiment station results might suggest were possible. A most significant finding is that at many study sites it would have been uneconomic for farmers to have increased input application to the level required to realize maximum yields. This is shown clearly in table 6, which indicates that the returns maximizing input levels were generally lower than those required to maximize yield per hectare. In the wet season it appears that use of inputs was not markedly below the economic optimum. Farmers used inputs at an economically rational level, rather than striving for

TABLE 4--Measured Potential Rice Yield[a], Actual Yield, Yield Gap[b] and Contribution of Three Types of Inputs in Experiments on Farmers' Fields, Wet Seasons, Selected Asian Sites, 1974-75

Location	Year	Trials (no.)	Yield (t/ha)			Contribution (t/ha) of			
			Farmers'	Potential	Gap	Fertilizer	Weed control	Insect control	Residual
Philippines									
Nueva Ecija	1974	10	1.9	2.3	0.4	-0.1	0.2	0.4	-0.1
Indonesia									
Subang	1975	4	2.2	2.4	0.2	0.1	-0.1	1.3	-0.1
Bangladesh									
Joydebpur	1976[c]	9	2.7	2.8	0.1	0.1	-0.1	0.1	0
Sri Lanka									
Giritale	1975/76	4	2.9	4.0	1.1	0.2	0.2	0.8	-0.1
Philippines									
Nueva Ecija	1975	11	3.2	3.9	0.7	0.3	0.1	0.2	0.1
Laguna	1974	10	3.6	5.6	2.0	1.1	0.3	0.8	-0.2
Laguna	1975	20	3.6	5.3	1.7	0.7	0.3	0.7	9
Camarines Sur	1975	6	3.6	4.6	1.0	0.4	0.1	0.6	-0.1
Thailand									
Supan Buri	1974	3	3.7	5.1	1.4	0.7	0.3	0.3	0.1
Supan Buri	1975	7	3.9	4.6	0.7	0.5	0.1	0.2	-0.1
Indonesia									
Yogyakarta	1974/75	3	4.2	4.7	0.5	0.7	-0.1	-0.1	0
Taiwan									
Taichung	1975	3	5.6	6.6	1.0	0.5	0.2	0.1	0.2

Source: Herdt (1976), table 4.

[a]The high input packages which produced the potential yields were not in all cases the highest input packages which could have been applied with positive marginal yield. Thus potential in this case is not strictly equivalent to maximum attainable yield.

[b]This refers to yield gap II.

[c]Aus season.

TABLE 5--Measured Potential Rice Yield[a], Actual Yield, Yield Gap[b] and Contribution of Three Types of Inputs in Experiments on Farmers' Fields, Dry Season, Selected Asian Sites, 1975-76

Location	Year	Trials (no.)	Yield (t/ha)			Contribution (t/ha) of			
			Farmers'	Potential	Gap	Fertilizer	Weed control	Insect control	Residual
Indonesia									
Yogyakarta	1975	2	2.6	3.9	1.3	1.0	0.4	-0.3	-0.4
Subang	1976	3	3.1	3.5	0.4	0.3	0.1	0	0
Bangladesh									
Joydebpur	1975/76[c]	6	3.5	5.2	1.7	1.3	0.4	na	0
Philippines									
Camarines Sur	1976	8	3.3	4.8	1.5	1.3	0.1	0.2	-0.1
Camarines Sur	1975	3	3.9	5.6	1.7	1.1	0.1	0.4	0.1
Thailand									
Supan Buri	1975	7	4.1	6.3	2.2	1.5	0.5	0.3	-0.1
Philippines									
Nueva Ecija	1976	8	4.2	6.2	2.0	1.3	0.3	0.6	-0.2
Nueva Ecija	1975	3	4.3	5.2	0.9	0.2	0.5	0.2	0
Laguna	1976	12	4.4	6.1	1.7	1.0	0.2	0.6	-0.1
Laguna	1975	9	5.6	7.4	1.8	1.3	0.2	1.0	0.1
Taiwan									
Taichung	1976	3	6.2	7.0	0.8	0.5	0.2	0.1	0

Source: Herdt (1976), table 5.

[a]The high input packages which produced the potential yields were not in all cases the highest input packages which could have been applied with positive marginal yield. Thus potential in this case is not strictly equivalent to maximum attainable yield.

[b]This refers to yield gap II.

[c]Boro Season

TABLE 6—Increased Profit and Rice Yield of Alternative Input Management Packages Compared to Farmers' Practices, from Experiments on Farmers' Fields, Selected Asian Sites, 1974-76

Location	Year	Trials (no.)	Increased net return per hectare over farmers practices					Increased yield (t/ha)	
			Units	M2[a]	M3	M4	M5	at max. net return[b]	at max. yield
					Wet seasons				
Philippines									
Nueva Ecija	1974	10	Peso	31	-358	-902	-2053	0.2	0.7
Nueva Ecija	1975	11	Peso	205	146	-178	-256	0.2	1.2
Laguna	1975	5	Peso	-841	-1751	-1262	-1056	0	1.3
Camarines Sur	1975	6	Peso	381	658	-158	-846	1.1	1.1
Thailand									
Supan Buri	1974	3	Bhat	336	836	-540	-2281	0.9	1.4
Supan Buri	1975	6	Bhat	-422	-1023	-3034	-4316	0	0.4
Indonesia									
Yogyakarta	1974	3	Rupiah	-14000	11330	-1660	10660	0.5	1.0
Sri Lanka									
Giritale	1975	4	Rupees	1528	1399	829	855	0.5	1.2
					Dry seasons				
Philippines									
Nueva Ecija	1975	3	Peso	-486	-522	280	357	2.1	2.1
Nueva Ecija	1976	9	Peso	a	820	1748	1864	2.3	2.3
Laguna	1975	9	Peso	-690	-666	-65	-768	0	1.5
Laguna	1976	7	Peso	a	1045	1296	2153	2.1	2.1
Camarines Sur	1975	3	Peso	-536	177	307	-181	1.5	2.0
Camarines Sur	1976	5	Peso	a	283	221	561	1.8	1.8
Thailand									
Supan Buri	1975	7	Bhat	365	488	-1167	-1455	1.1	2.2
Indonesia									
Yogyakarta	1975	2	Rupiah	22000	51000	80000	157000	2.7	2.7

Source: Herdt (1976), table 6.

[a]M2, M3, M4 and M5 are increasingly higher combinations of input management packages.

[b]Note that for the dry season at the majority of centers the economic optimum yield increase exceeds the yield gap shown in table III.11. At several centers this may partly reflect a change in sample size, but in general is due to the point raised in footnote (a) in tables III.10 and III.11.

maximum yields through high levels of input use. In the dry season the highest input levels were economically justified in 5 of the 8 areas studied.

It should be recognized that the rice acreage in the dry season is appreciably smaller than that in the wet season, and that increases in dry season yields will have only a comparatively small effect on annual average rice yields. It is estimated that for the period 1970-75, only 7.4 percent of the rice acreage of all Asian countries was double cropped in the dry season. (Of an estimated total rice area of 78.3 million hectares, only approximately 5.8 million were double cropped with rice.)

It should be observed that though the potential for increased yields is greatest for the dry season, it is still comparatively small. This is shown in table 7, in which the second crop can be taken as being equivalent to the dry season irrigated acreage. On this basis it can be estimated that for the 11 countries listed, the dry season irrigated acreage amounted to only 22 percent of the wet season irrigated acreage, and to only 7.4 percent of the total wet season acreage. The same data also show clearly that the optimal habitat for MV--irrigated land--comprises only 34 percent of the rice-growing area in the wet season. The dominant land category is rainfed, which accounts for 51 percent of the wet season area. It is clear, therefore, that further research to develop superior technology for growing rainfed rice is likely to contribute significantly to lifting constraints to the further adoption of modern inputs in rice production.

The dominant reasons for the low level of input adoption revealed by the IRRI study were poor water control, lack of knowledge, infrequent

TABLE 7--Estimates of the Proportion of Rice Area in Five Major Environmental Categories, 11 Asian Countries, 1970-75

Country	Total rice area ('000 ha)[a]	Proportion of area				
		Irrigated	Rainfed	Upland	Deep-water	Second crop
				(%)		
India	37,755	40	50	5	5	5
Bangladesh	9,766	16	39	19	26	10
Indonesia	8,482	47	31	17	5	19
Thailand	7,037	11	80	2	7	2
Burma	4,985	17	81	1	1	1
Philippines	3,488	41	48	11	0	14
Vietnam[b]	2,713	15	60	5	20	5
Pakistan	1,518	100	0	0	0	0
Nepal	1,200	16	76	9	0	0
Malaysia (W)	771	77	20	3	0	50
Sri Lanka	604	61	37	2	0	25

Source: Herdt (1976), table 1.

[a]1970-74 average area, FAO data.

[b]Former South Vietnam.

extension contact, difficulties in obtaining credit, and problems of obtaining inputs on time. It is important to note that these constraints are largely outside the control of farmers and do not imply inefficiency or ineptitude on their part. It is, however, within the realm of policy to expand credit facilities, increase extension services, and improve the input supply system, although the IRRI research suggests that the returns to such policy developments may be modest.

Though the IRRI research did not explore constraints to the adoption of MV, this aspect was examined by Pachico (1979), in a study of the middle hills of Nepal. Pachico's research concentrated on the factors determining the proportion of the wet season lowland rice acreage allocated to each of three rice varieties--Taichin, a nitrogen-responsive dwarf variety; Pokhareli, a comparatively high yielding Nepalese variety; and Thapachinia, formerly the most commonly grown local variety. Of these, Taichin is the highest yielding, though it is more difficult and time-consuming to thresh than the lower yielding Pokhareli. Taichin's slightly shorter growing season also makes it an attractive variety, offsetting the fact that it has somewhat poorer taste and cooking qualities. Pokhareli requires more transplanting labor than Taichin, and the Pokhareli plants are frequently bound together before harvest to prevent lodging. This practice amplifies labor requirements before and during the harvest period. The seasonal labor requirement profiles of the two main varieties are therefore distinctly different. Thapachinia, the local variety, has markedly lower yields than Pokhareli, but it also has a much shorter growing season and excellent cooking qualities. As a consequence of the interaction of these varietal differences, a place exists for each of the varieties within the system, although Taichin is dominant. The complexity of the interactions can be illustrated with three points: (1) the higher yielding Taichin is preferred by small farmers operating close to subsistence, but with adequate family labor to cover the harvest peak; (2) larger farmers, who must hire labor, react to the cost and difficulty of obtaining harvest labor by growing a relatively high proportion of Pokhareli, which has a lower harvest labor requirement than Taichin; and (3) larger farmers combine a higher proportion of Thapachinia with the other two varieties because its early maturation spreads the harvest labor peak, and it supplies fresh rice at an earlier date for festivals. These findings give an indication of the constraints that exist to the introduction of a new variety, such as Taichin, into an existing farming system. Such a system operates within certain patterns of labor availability and food needs, which dictate the use of a combination of varieties rather than one single variety, and so represent constraints to the complete adoption of any new high yielding varieties.

It has already been noted that the economically optimum level of input use is sometimes lower than might have been expected, and that economic considerations impede the adoption of technology. However, the economic optimum is a function of the price of rice, the prices of inputs, and the cost of credit. In many cases these are largely determined by agricultural and industrial pricing policy, and as has been reported, these prices do appear to be discernably related to the levels of adoption of the new technology. Thus, the economic constraints to adoption perceived by farmers are to a large extent determined by policymakers, and are outside the control of farmers.

The Hart (1978) and Ranade (1977) studies used production function analysis to examine economic and technical efficiency in the use of factors of production. Their findings are of greatest interest relative to the use of labor. Hart found that with respect to labor, larger farms tend to operate at a point which is sub-optimal in terms of profit maximization. Her empirical results cast doubt on the presumption that very small farms tend to be inefficient and suggest, in fact, the opposite. The analysis also indicated that the marginal value product of rice labor in this Indonesian village is far from zero. In the case of activities performed by males, increasing labor inputs per hectare did not decrease the marginal value product of labor, whereas it did produce significantly higher yields.

In the Philippines, Ranade found that farmers using traditional technology operated at the optimum level for labor use, given their supply of land. It was concluded that laborers were not paid less than their marginal product on either traditional or mechanized farms. The analysis showed that modern technology was both land and labor-saving. The land-saving bias substantially outweighed the labor-saving bias. In both areas, production function analysis bore out the conclusion that farmers were rational in their use of labor in combination with available land and other inputs.

The Effects of Technology on Income, Employment, and Factor Returns

Clearly the new rice technology should not be examined as if it were an indivisible whole, but rather the separate components of that technology must be studied. With survey data, it generally proves too difficult to disentangle the separate effects of new varieties, fertilizers, tractors, pumpsets, etc., and some compromise is necessary. Such compromises were certainly adopted by Ranade (1977) and Doraswamy (1979) in their studies of the impact of technological change in the Philippines and India. In Ranade's study of Laguna and Central Luzon, the combined effect of the adopted package of technology on employment, and the revenue accruing to the various factors of production, as well as the different socioeconomic classes, was examined. In addition, there was extensive analysis of the effects of tractors and mechanical threshers, plus some partial results for the effects of irrigation and the use of chemicals (including fertilizers, insecticides, and herbicides).

In Doraswamy's study of Chittoor District, India, attention was focused principally upon the effects of mechanization in the form of tractors on employment, output, and cropping patterns. Doraswamy's study is especially interesting in this latter regard, for unlike the studies by IRRI, and those by Ranade (1977) and Hart (1978), which took place in areas where rice was virtually the sole crop, the Chittoor District study examined a situation where rice was only one of a number of major crops (the other being sugar cane, groundnut, and other grains), thus permitting analysis of the effect of tractors upon cropping patterns and intensity.

Ranade's results for the Philippines confirmed that in irrigated areas, farmers adopting MV and fertilizers can expect marked increases in yield and higher net returns. In fact, over the study period it appears that the adoption of these inputs increased average yields by up to 50 percent, and benefited all participants: landlords, tenants and landless laborers. It was determined that there were positive returns to the factors of production themselves, i.e., it was economically rational to use fertilizer, insecticides, and herbicides. The distribution of the additional output between the different factors and the different participants was by no means equal. This, however, was due in part to a highly effective land reform scheme carried through in the Philippines, which disadvantaged landlords and favored operators.

In the Philippines it was expected that MV, fertilizer, and irrigation would have significant output-increasing effects; this is entirely consistent with other survey results, including those published by IRRI. Ranade's findings with respect to the impact of mechanization can be summarized as follows:

--There is no evidence to suggest that the use of tractors or mechanical threshers has a positive effect on rice yields.

--Tractors in the Philippine study were not employed in activities other than land preparation, and they substituted for labor, mainly from the operator's family, in this task. The reduction of labor demand for this task on tractor using farms tended to be more than offset by increased demand for labor (mainly hired) in planting, weeding, and harvesting. None of these latter effects can, however, be attributed to the use of tractors. The first two were probably due to improved husbandry practices such as the adoption of straight-line planting and row-by-row weeding; and since there was no evidence that tractor using farms had higher yields, the reason for the latter effect is unclear.

--Since hired labor constituted a high proportion of harvesting and threshing labor, the employment effect of threshers fell mainly on hired labor. This contrasts with the effects of tractors, and suggests that the effects of threshers upon income distribution are socially much less attractive than those of tractors.

--In Central Luzon, the shares of operators and operators' residuals were appreciably higher on farms employing tractors than on non-mechanized farms.

--The use of threshers was associated with operators' shares and operators' residuals even higher than those on farms using tractors only. This suggests the existence of a strong private incentive for the adoption of threshers in Central Luzon, against which the social cost of job displacement must be set in perspective.

--As a result of changes in the labor task composition due to mechanization, average wage rates were lower on tractor using farms than on non-mechanized farms, and even lower on farms employing mechanical threshers. From the standpoint of the welfare of hired laborers, this is a most interesting finding which does not appear to have been considered in other studies.

Doraswamy's results for the impact of tractor use in Chittoor District, India are very much in the same vein as for the Philippines. Again, tractor use in crop production was found to be almost exclusively confined to the plowing operation. Hence the only crop operation in which tractor use was found to significantly affect (reduce) labor demand was plowing, and since plowing labor constituted an average of only 5 percent of labor demand, the effect on the total labor required for any particular crop was small. The possibility therefore, was that the main effect of tractor use on labor demand might be to change the composition of crops produced and to increase the proportion of those requiring more labor.

An interesting analytical technique was conducted to test this hypothesis, with the expectation that if the use of tractors for plowing showed any effects on cropping patterns it would be for one of two reasons: (1) Because of its effect on timeliness, it might permit expansion of the acreage of crops with a short plowing to sowing interval--primarily paddy on wet land and groundnut on dry land, and permit expansion of crops which are highly specific with respect to planting date--this applies chiefly to groundnut on wet land. (2) Because it reduces labor and bullock requirements for plowing, it might permit expansion of the acreage of paddy, which has an especially high demand for plowing time. A third effect might also have been expected: the possibility that acreage used to produce forage for draft animals would be freed for the production of other crops. This was not the case, since in the study site draft animals are fed largely on grain stubble, and there is, therefore, little forage acreage to displace. It was anticipated that any crop effects of mechanization would show up largely in increased paddy and groundnut acreages. This in fact was what the statistical analysis showed, but the effects were undramatic and in several cases not significant.

The main results of this analysis can be summarized as follows:

--In general, the net effect of tractorization on plowing labor demand was negative; the change to crops requiring more plowing labor was outweighed by the displacement of labor in the plowing operation.

--The main crop effect associated with tractorization on labor demand was found in all non-plowing operations, and this was positive in most cases. The largest of these effects was found to be on tractor hiring (as opposed to owning) farms. The increase was 28 percent on farms owning tractors and 70 percent on farms hiring tractors.

--One of the notable features of the results was that from the point of view of increasing hired labor demand, the hire of tractors was more favorable than ownership, since farms hiring tractors used them more sparingly than owning farms. Consequently, in most cases it was found that ownership of tractors decreased total labor demand more than tractor hiring.

--If the four Indian sites are aggregated, it appears that tractor hiring was associated with some increase in total (plowing and non-plowing) labor, but the effect was not marked. No such conclusion is possible for tractor ownership.

--In view of the difficulty which is usually encountered in separating the employment effects of tractorization from (the independent) yield effects, it is worth noting that Doraswamy's procedure successfully differentiated the separate effects.

The results obtained by Ranade (1977) and Doraswamy (1979) confirm that tractors are not necessary for increased rice output in the areas studied. They also fit into the pattern of results presented by Binswanger (1978) in his recent review of over one hundred studies of the effects of tractors in South Asia. He concluded that:

> The tractor surveys fail to provide evidence that tractors are responsible for substantial increases in intensity, yields, timeliness, and gross returns on farms in India, Pakistan and Nepal. At best, such benefits may exist but are so small that they cannot be detected and statistically supported. . . . Indeed the fairly consistent view emerging from the surveys largely supports the view that tractors are substitutes for labor and bullock power, and thus implies that, at existing and constant wages and bullock costs, tractors fail to be a strong engine of growth. They would gain such a role only under rapidly rising prices of those factors of production which they have the potential to replace. (Binswanger, 1978, p. 73)

The results could be interpreted as indicating that tractor mechanization is neutral in a rice-based economy; however, this conclusion must be tempered by two additional considerations. First, at present the use of tractors appears to be primarily confined to plowing. It can only be assumed that in order to make better use of tractors, the range of activities in which they are employed must increase, with a resultant increase in labor displacement. Second, although adoption of tractors may not appear to reduce the demand for hired labor in the areas studied, the supply of hired labor has increased rapidly as a consequence of population growth. Thus, to the extent that tractor use has retarded growth in labor demand it has important social implications.

The Economic Condition and Behavior of Different Socioeconomic Classes

The distributional impact of technological change upon different socioeconomic classes is conditioned by (1) any scale biases in that technology; (2) any biases in the institutions involved in the factor and product markets; and (3) by differences in the economic behavior and reactions of the different socioeconomic classes. This latter topic has been the object of an in-depth study by Hart (1978) in Indonesia, with complementary findings emerging from the other studies. The research findings provide a valuable background for any consideration of distributional issues relating to rice technology. Hart's study illuminates the marked differences in the capacities of the different classes to advance themselves, by demonstrating the relative lack of dependence of the richer members of the rural community upon the poorer. Hart's analysis indicates that social and technical changes are weakening the dependency between classes.

Three classes of households were identified in the Indonesian village. These classes were based on ownership of land sufficient to generate various levels of income. The poverty level is defined as income equivalent to the value of 300 kg milled rice per consumer unit, and subsistence as an income equal to 150 kg milled rice per consumer unit--the quantity necessary to meet basic staple food requirements. Class I households were those with adequate land to produce income equivalent to or greater than 300 kg per consumer unit. Class II households were those with sufficient assets to enable production in excess of the staple food requirement of 150 kg milled rice per consumer, while Class III households were those controlling insufficient assets to meet even staple food needs. The percentages of households in each of these classes were approximately 24, 33, and 43 percent, respectively. Given that the principal productive asset determining asset status was agricultural land controlled, it is evident that the largest class, Class III, consisted essentially of landless families who had to find wage employment, or some role in the informal sector to attain even subsistence levels of consumption. While a further third of households operated small amounts of land and generated sufficient own-production to cover subsistence needs, they also needed to find employment in order to achieve the poverty standard of consumption.

Hart observed major inter-class differences in employment patterns, and the nature and extent of these differences is particularly interesting. In terms of hours worked, class differences were found to have the least effect upon men, for whom only a small direct relationship was noted between hours worked and class. Naturally, however, the nature of adult male employment differed greatly with asset status, with men from Class I spending 87 percent of their time working with their own assets, while men from Class III spent 91 percent of their income earning time in wage employment (see table 8).

However, in terms of income earning contribution, the main impact of class was revealed in the economic role of women and children whose contribution increased substantially as asset status declined. Indeed, in the poorest families there was surprisingly little difference on average, be-

TABLE 8—Average Hours Worked per Year at Different Job Types, by Class, Sex, and Age, Village A, Central Java, Indonesia

Class		Hours per Household	Hours by Females	Hours by Males	Average Hours per Person				
					Persons 9 yrs	Girls 10 - 15	Women 16	Boys 10 - 15	Men 16
Own Production[b]	1	3,813	321	3,492	1,048	44	242	508	2,246
	2	1,567	240	1,327	431	44	183	432	839
	3	299	59	240	92	17	46	178	141
Trading[b]	1	615	462	153	171	0	369	0	108
	2	448	418	30	122	43	325	36	1
	3	237	170	67	75	5	132	14	56
Wage Labor[b]	1	552	222	330	153	54	158	52	209
	2	2,798	996	1,802	771	416	641	304	1,291
	3	4,164	1,984	2,180	1,290	1,168	1,202	554	1,706
Gathering[b]	1	65	45	20	19	23	28	22	5
	2	341	224	117	94	172	97	97	45
	3	467	277	191	147	169	162	124	120
Ocean Fishing[b]	1	29	-	29	9	-	-	32	9
	2	582	-	582	160	-	-	421	265
	3	536	-	536	169	-	-	461	290
All Income Earning Activities[b]	1	5,074	1,050	4,024	1,400	121	797	614	2,577
	2	5,736	1,878	3,858	1,578	675	1,246	1,290	2,441
	3	5,703	2,499	3,214	1,773	1,359	1,542	1,331	2,313
Housework[a]	1	1,812	1,666	145	499	362	1,216	31	90
	2	1,589	1,443	146	437	438	1,003	57	82
	3	1,254	1,173	80	390	392	800	37	61
All Activities[b]	1	6,886	2,716	4,169	1,899	483	2,013	645	2,667
	2	7,325	3,321	4,004	2,015	1,113	2,249	1,347	2,523
	3	6,957	3,672	3,294	2,163	1,751	2,342	1,368	2,374
Travel to and from Work	1	713	126	587	nc	nc	nc	nc	nc
	2	723	229	494	nc	nc	nc	nc	nc
	3	690	291	399	nc	nc	nc	nc	nc

Source: Hart (1978), pp. 124, 126, 128.

[a]Hours per male < 10.
[b]Including travelling time.
nc: not calculated.

tween the total working hours of any type of family member over nine years of age. Boys in Class III were recorded as averaging 1,368 hours of work per year, girls 1,751 hours, women 2,342 hours, and men 2,374 hours. This contrasts with the comparable figures for the richer Class I households of 645, 483, 2,013, and 2,667 hours, respectively. Thus women and children in families with little land were forced to participate extensively in income earning activities. It is important to add that despite their efforts, the average Class III household only achieved an average income of 274 kg milled rice equivalent per consumer, which was below the 300 kg poverty level. Moreover, because of their need to find a relatively sure source of income, members of poor families (particularly women and children) exhibited a tendency to accept low wages in return for some security of employment. These and related findings assume particular significance within the context of Hart's study, since they support the main conclusion of her theoretical model that households with no or few productive assets will be forced by survival considerations to participate continually in the labor market, even if this involves working long hours for very low returns. It is also significant that it was women, elderly males, and children who provided this anchor role for the household economy leaving men, who had a wider range of income earning opportunities, to participate in higher return employment. In striking contrast, ownership of even very small amounts of land allowed household production of rice at a subsistence minimum, thereby making it unnecessary for women of Class II households to participate in low-wage contract labor.

There is a further noteworthy economic dimension to the extensive participation by the 10 to 15 year-olds in Class III households in the labor market; this is that it restricts their attendance at school, thereby limiting any opportunities to escape from their poor circumstances through education. Thus, they are effectively caught in a low-income trap. This is reinforced when it is noted that Hart observed that even children below 10 years of age played an indirect but important role in the economy of the poorest households. In the poorest households, children between the ages of 6 and 9 were responsible for looking after younger siblings in order to free mothers for paid employment.

The overriding impression presented by Hart's study is of family members forming in an integrated work team, with individuals adopting roles which permit the family, as a unit, to maximize income and security of work. Furthermore, the observations support the theoretical hypothesis that this behavior is dictated by poverty, and that the degree of coordination within families declines as their productive asset base increases.

It is also worth noting that the conclusion regarding the economic role of women and children within the family is also supported from an entirely different standpoint by a hypothesis proposed by Doraswamy (1979), in his study of mechanization in Chittoor District, India. The situation there is essentially one of a much higher level of affluence than that found in Indonesia, and is one in which educational levels are higher. Based on cross-farm analysis, Doraswamy hypothesizes that increased school enrollment may cause increased mechanization on farms by reducing family labor availability. It does this by removing children from direct participation in farm work, but more importantly it necessitates the withdrawal of women's labor from the farm in order to take over the child care formerly performed by older children.

Class differences in household work patterns are not solely the direct product of asset ownership and household preferences; they can also be influenced indirectly by asset ownership. This is to say, as Hart (1978) argues for the Indonesian case, that there are restrictions (or preferences) on access to jobs which depend upon class (asset ownership). Hart identified a number of mechanisms for the distribution of patronage in assigning available work. The overriding effect of these was that the small land-operating households in Class II had an advantage over the landless Class III households in gaining access to the employment offered by large landowners. One result of this was the systematic tendency of wage rates paid to Class II members to exceed those for Class III. The existence of these biases calls into serious question the notion that in traditional rural systems, institutions exist to share work with the poorest. Instead, what exists is a highly competitive labor market into which are built mechanisms which actively discriminate against landless households.

The Influence of Technological Change on the Labor Market and Other Institutions

It has been observed that the distributional consequences of technological change are, in part, a function of institutional arrangements in the factor markets. This is especially true of labor markets, and it is therefore important that significant changes were observed in the arrangements for hiring and paying harvesting labor in Indonesia and the Philippines. Harvesting labor is the main source of wage employment for landless laborers.

A major change which has been observed in both countries is the moving away from the traditional situation where anyone who wished to participate in a farmer's harvest could do so in return for a pre-determined share of the harvest, to one in which there is restriction on who is permitted to undertake harvest work. In addition, the changes serve to restrict the share of the harvest which is paid for harvesting labor. More specifically, in Indonesia a change has been observed from the traditional bawon system, in which harvesting was open to all, towards closed bawon systems, in which only certain people can participate, and more significantly to the tebasan system, in which the landlord pays a contractor to organize the harvest. These changes have been accompanied by a reduction in the share of the harvest paid out to labor, although to the extent that yields have increased this does not necessarily signify that total payment to harvest labor has declined. In the Philippines (among other changes) there has been a movement away from the system in which all could participate in the harvest in return for a sixth share, to a system in which workers must provide free weeding labor during the growing season in order to participate in the harvest and receive the one-sixth share.

Although these institutional changes cannot be wholly attributed to the introduction of new rice technology, it seems entirely reasonable to argue that it has provided a significant stimulus for them. Given that the higher yields obtained with the new varieties are not primarily attributable to harvesting labor, there is an obvious rationale for reducing the share of production distributed to such labor. The changes noted in Indonesia and the Philippines have provided an effective means of accomplishing this. Of course the other major incentive for these changes has been the growth in the number of landless people and those with inadequate productive resources of their own. This has swelled the supply of harvesting labor to the point where some mechanism, other than price, for rationing available work has become necessary in certain places.

It is debated by Hayami and Hajid (1978) whether these institutional changes, caused in part by changing rice technology, can be interpreted as being biased against the landless and other poor. It is certainly conceivable that if the price of harvesting labor were allowed to find (fall to) its equilibrium level, total returns to labor might be lower than in the emerging labor rationing systems. Nevertheless, these institutional changes do represent some breakdown of the paternalistic ethic which has often been assumed to operate in rural communities. They discriminate against potential poor job seekers, and they represent a significant element of the process whereby economic change excludes poorer people from its benefits.

The raising of this issue of marginalization through institutional change, and through the way in which economic institutions and relations operate, indicates a shortcoming in the work summarized here. In the studies reported, no results have been obtained regarding possible impacts of the new technology upon the size distribution and number of holdings, or upon the pattern of control over land and wealth in general. Rather, the inquiry has been from the opposite end, how the adoption of technology is influenced by these factors. That there is an expanding literature (especially for areas of Asia, where mechanical technology has been introduced) which suggests that the new technology intensifies forces leading to concentration of land ownership/control, and to increasing inequality in incomes. The main reasons for such tendencies are thought to be attributable to the large farm biases in factor markets, and this is particularly true of credit used for the purchase of tubewells, tractors, pumps, fertilizer, etc. If such tendencies are inherent in the new rice technology, as authors such as Griffin (1974) argue that they inevitably are, then any adverse distributional consequences noted for the new technology in this summary would be increased.

It would be anticipated that the higher yields resulting from adoption of the seed-fertilizer technology would be accompanied by increased labor demand. It is here that the difficulties of disentangling this effect from the labor demand effects of other technological changes presents problems. While the Cornell research does not address this issue directly, evidence from other sources does indicate that adoption of MV and higher fertilizer use increases labor demand, but this increase is proportionately smaller than the increase in yields, so that labor input per ton of rice declines.

Policy Implications

The research conducted by Cornell provides support for the prevailing view that the new rice technology has had a significant positive impact on rice yields, output, and to a lesser extent, employment in South and Southeast Asian countries. It is also apparent that there is further progress to be made, since the use of modern varieties (MV) and associated inputs could be increased in many countries. This is particularly true, since use of the associated inputs (fertilizer, insecticide, and improved weed control) are apparently being used below economically optimum levels. Care must be taken not to exaggerate the potential for further development with the current MV and technology. The main thrust of plant breeding research to date has been directed to rice varieties with high fertilizer response on irrigated land, while less research has been directed at increasing potential yields for rainfed, upland, and deepwater rice varieties. The potential yields of MV are appreciably higher for the dry season irrigated rice crop than for the wet season crop. It should be noted that the dry season irrigated rice acreage is relatively small compared to wet season irrigated acreage (see table 7). Furthermore, it was found (table 6) that in the wet season, farmers who grew MV were applying associated inputs at levels far closer to the economic optimum than might have been expected. In part, this is because the economically optimum application of inputs from the farmers' points of view was less than the level required to maximize yields per hectare. In the dry season, it was found that the extent to which farmers were using input levels below the economic optimum was more marked. The principal restrictions on this acreage are (1) that in the colder northern latitudes in Asia the dry season is too cold and has too short a growing season for rice, so that any second irrigated crop must be hardier than rice (e.g., wheat); and (2) that water supplies are inadequate to provide irrigation for significant portions of the area during the dry season. To lift these restrictions calls for further research to develop cold resistant varieties, and also for more investment in irrigation, where this can be economically justified.

The research also indicates that farmers in Asia have been highly receptive to the new seed-fertilizer technology, have reacted rapidly, and are very capable of perceiving what is to their economic advantage. Evidence of this has emerged in a number of ways. First, adoption of inorganic fertilizer and other new inputs had been quite extensive in some areas prior to the drive to introduce MV. Adoption of MV has proceeded rapidly since their introduction in 1966, and there has been a rapid further increase in the use of other modern inputs. It is also notable that the smallest farmers appear to have been the most avid adopters of the seed-fertilizer technology, applying their abundant family labor to these and traditional inputs at higher levels than larger farmers, and obtaining higher yields. Indeed, the evidence supports the position that breaking up larger holdings will result in increased production. Certainly the land reform carried out in the Philippines appears to have been successful in the study areas and to have had no adverse impact on production.

It is particularly relevant for policy that the constraints causing farmers to underemploy resources were found to be largely outside their control, but susceptible to policy action. In some cases, significant numbers of farmers were found to be ignorant of the economic possibilities of the new technology. While from one standpoint this could be interpreted as a reflection on the drive and initiative of farmers, from another, it reflects weaknesses in the institutions which disseminate technical and economic information. Many farmers were aware, however, that higher returns could be expected from employing more inputs. Risk (an uncontrollable factor) was one reason given as inhibiting higher input use, but from the policy standpoint it is more significant that the cost and availability of credit, and the physical non-availability of inputs at times when they were wanted appear to have been major constraints to higher input use. There are economically rational reasons for not fully adopting the modern rice varieties. Such reasons were identified by Pachico (1979) in Nepal, and help to explain the rationale for continuing to plant some of the rice acreage to traditional local varieties. These reasons suggest that expectations about the potential penetration of MV should be tempered.

At an even higher level of policy, it should be observed that the economic returns from adopting technology are directly influenced by political intervention in factor and product markets. It is not uncommon to observe government agencies exhorting farmers to greater efforts, while pursuing pricing policies which restrict the economic returns to such efforts. This observation is particularly significant in that technically feasible rice yields are held up as targets, but they may exceed the economic optimum. Changing policy-determined prices will change the economic optimum production levels of farmers.

It should be emphasized that the modern technology being applied to rice production is not an indivisible set of complementary inputs. It is true that there is a very high degree of complementarity between irrigation facilities, MV, and inorganic fertilizers. In certain localities insecticides, and less frequently, mechanization may be highly productive. From a social welfare standpoint, the most questionable inputs are tractors and mechanical threshers, which only appear to be crucial complements in special situations. Tractors are being increasingly adopted in most rice growing areas, and mechanical threshers are also being used in a few countries. The evidence, however, suggests that in most of the areas where mechanization has occurred its impact on yields is negligible, but more critically mechanization has had no detectable influence on the potential for double cropping in rice production. The social benefits from mechanization thus appear to be rather small, in general, although they may be high in special circumstances.

The private benefits of mechanization are evidently high. This appears to be especially true of threshers in the Philippines, where their labor-saving effect was observed to be large. In contrast, the labor-saving effect of tractors was found to be quite modest and to be confined almost entirely to land preparation activities, which account for a small proportion of total labor demand. This contrasts with the impact of tractors in wheat-growing areas of Asia, in which larger four-wheeled tractors are being used for a wide range of cultural tasks. In the few areas of

South and Southeast Asia which still have relatively favorable land-labor ratios, the divergence of private and social returns to these mechanical technologies may be small at this stage, but in more densely populated areas the divergence may be large, and be exacerbated by policies of cheap credit and subsidies on inputs. In such areas, the spread of mechanical technology should be geared to the size of social returns and policy should be directed to reducing the gap between these and private returns.

This last observation raises the issue of the distribution of the benefits of the new technology; that is, of how the returns are distributed between different socioeconomic groups. This is of particular significance against the background of increasing rural landlessness in large parts of Asia and the fact that while the economies of virtually all Asian nations are growing, the absolute number of people living in abject poverty is expanding. Thus, critical issues for policy are whether additional employment for hired laborers, and particularly landless laborers, is created, and also of whether the new technology sets up forces leading to further concentration of land control and increasing landlessness.

Regrettably, no complete answer to these questions is possible, but there are a number of partial indicators which are suggestive. Cornell research conducted in the Philippines (Ranade, 1977) concluded that all relevant socioeconomic groups (landlords, operators, hired labor, and input suppliers) have gained where the seed-fertilizer package has been adopted, although the size of these gains has been affected by the land reform program which restricts the extent to which the results can be generalized. What is clear, however, is that the seed-fertilizer technology has resulted in higher yields, and in an associated increase in total labor demand, although labor requirements have increased at a slower rate than yields. Hired labor demand, however, has been observed to increase at a faster rate than that for total labor, since there appears to be a discernable tendency for families operating larger land areas to decrease the amount of family labor performed by sending their children to school, by reducing female labor input, and by diverting some male labor to other activities. Nevertheless, the rate of increase in hired labor demand remains less than the increase in yields.

Hart's (1978) study in Indonesia has provided evidence that the landless do not benefit from the increase in labor demand to the same degree as small farm operators, and that large land operators exhibit a bias in favor of those owning land in their hiring policy. This suggests important implications relating to policy decisions which promote rural employment through public works projects, such as construction of roads, dams, or educational facilities. Few rural people view public works employment as permanent or reliable. Consequently, the "survival strategy" of the landless would probably induce them to maintain established work patterns. In contrast, self sufficiency in rice production places small landowning households in a stronger position to accept the risk associated with this employment. Even if the landless are willing to disregard job uncertainty, there is reason to suppose that unequal work opportunities would operate against them. It therefore appears that public works projects would be only marginally successful in providing increased employment for the landless.

When tractors are employed in conjunction with the seed-fertilizer technology, the increase in labor demand is moderated somewhat. Where threshers are employed, there is a marked saving in threshing labor on a scale which may be sufficient to nullify the demand increasing effect of adopting MV with fertilizer. In addition, where machines are employed, there is evidence from Ranade's (1977) work in the Philippines that average wage rates are reduced. Presumably this is due to the changing task composition of the work performed towards traditionally less well-paid tasks, for example, weeding. This cannot be interpreted as being due to the direct effect of mechanization on the average price of rural labor, although the wage rate has been recorded as declining in real terms in several Asian countries. The latter is evidence that the growth of agricultural labor demand in rice growing areas in the poorer Asian countries has not kept pace with the growth in labor supply. Undoubtedly the adoption of modern rice varieties, fertilizer, and irrigation have ameliorated this position somewhat.

The main gains from the new technology appear to have been made by land operators and landowners rather than by labor. This raises the important issue of whether the institutions organizing the diffusion of the technology have a built in bias towards large land operators and against the small farmers, despite evidence that the latter tend to achieve higher yields with the new varieties. There is also the ancillary question of whether the new technology actually serves to heighten this bias in some way, despite the inherent scale neutrality of modern varieties and chemical inputs. The studies undertaken were not specifically directed to these questions, but they have produced a number of relevant insights. In both the Philippines and Indonesia, similar changes were observed in the institutions governing the harvesting of rice. These involved a shift from traditional systems, in which the harvest was available to laborers willing to work for a traditionally determined share of production, to more restricted arrangements. These new arrangements involve reducing the share of the harvest paid to labor and in various ways controlling access to harvesting work. It is not surprising that labor's share of the harvest would be reduced, since the higher yields associated with MV are not attributable to labor; thus in part, the new technology has provided a stimulus for the abandonment of harvesting arrangements, which in their original form guaranteed the landless some rice. It should be kept in mind that preservation of traditional relationships is increasingly unmanageable, due to the rapid increase in total labor, and particularly landless labor.

The new technology has provided an excuse, as well as a stimulus for erosion of patron-client relationships, which can be interpreted as a breakdown in the traditional arrangements whereby the community assisted its poorer members. The adoption of tractors and threshers reflects something of the same phenomenon, in that it permits farmers to overcome difficulties in adjudicating the issue of who will be hired in a labor surplus situation, and provides yet another incentive for setting aside traditionally recognized rights. From a policy standpoint this is an undesirable secondary consequence of the adoption of these mechanical technologies, especially if their social returns are small, and it underscores the desirability of pursuing policies which keep the gap between private and social returns negligible. Noting that the social cost of mechanical threshing is particularly high, Ranade suggested the possibility of landless laborers forming cooperative units which, with government-backed low interest loans, could purchase mechanical threshers. The landless might then capture a portion of the private benefits accruing from the ownership of labor-saving threshing equipment.

Although the key input of the new rice technology--water, seeds, fertilizer, and insecticides--are highly divisible, can be supplied in small quantities, and are inherently scale neutral, it has nevertheless been widely accepted that there is a bias towards larger holdings in the economic processes set off by the new technology. In part, this is because the means of delivering water do not always lead to equitable distribution; there is a minimum size of holding required to justify the acquisition of tubewells and pump sets.

Where tractors and threshers are important elements of the technology, this problem of technological indivisibility in private ownership becomes even more acute. It is, however, also evident that in certain areas, this large farm bias is reinforced in the provision of credit for the purchase of the divisible inputs; subsidized government credit may be available more readily and cheaply for large landowners with extensive holdings for collateral.

In this situation small farmers, despite their demonstrated industriousness, may be trapped into situations of indebtedness, where they are forced to mortgage or sell their land to larger landowners. Clearly, the new technology has intensified this tendency to increasing concentration of land control, by raising the returns to land and providing the incentive to the larger land operators, who have the economic power, to increase their holdings. It is concluded that strong public policy must be formulated in a manner which will build-on the scale-neutral aspects of agricultural technology, and direct benefits towards small farmers and landless families.

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POOR RURAL HOUSEHOLDS, TECHNICAL CHANGE, AND INCOME DISTRIBUTION IN DEVELOPING COUNTRIES: INSIGHTS FROM ASIA

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I. AN OVERVIEW OF THE RESEARCH AND STUDY AREAS

Introduction

The purpose of this report is to assess how the adoption of improved agricultural technology has influenced production and income distribution on small Asian farms and among the landless. The people of Asia constitute approximately 60 percent of total world population. Not only is the Asian population immense, its land mass is vast, and its agriculture varied. One factor serves as a common denominator for this disparate group of nations and people--rice. The research discussed here concentrates on wet-land rice production, for this is the crop around which most agricultural activity revolves in virtually all parts of Asia. For the area as a whole, cereals constitute over two-thirds of total caloric intake, with rice providing 60 percent of all grain production and consumption.

Those first men and women who paused in their wandering, gathering, or slash and burn agriculture to consciously plant rice seeds and nurture them through to harvest, made the supreme contribution to the well-being of their successors. In terms of feeding man, their efforts were more important than control over fire, the wheel, or smelting iron. For countless generations trial, error, luck, and misfortune have combined to produce what we will refer to as traditional rice technology. Locally adapted varieties were selected--fast-growing tall fellows with long drooping leaves to keep their heads above water and shade competing weeds. Nursery beds were developed to give the seedlings a head start at the time of planting; and precise plant spacing and weed control increased yields, as did the careful timing and flow of water within the laboriously constructed paddies. Rice yields per hectare rose with population and labor supply, but eventually biological limits created a yield plateau.

Over the past decade the adoption of modern varieties (MV) and the associated use of fertilizer, agricultural chemicals, and water management techniques have increased Asian rice yields and total production significantly. The added output has also served to limit price increases for those who must buy their staple food. With the advent of adoption of technical improvements in rice production, there has been increased concern as to the way in which the benefits have been distributed among rural families with varying control over land and other productive assets.

The performance of Asian nations in adopting new technology to keep rice production ahead of population has been highly variable. The figures presented in table I.1 provide a very simplified overview of percentage changes in food production, population, and domestic food demand for selected Asian countries during the period 1952-1976.

Admittedly, food refers to more than just rice. The nations vary somewhat in their dependence upon rice as a staple; however, food as measured here is a fairly accurate reflection of trends in rice production and demand. It should be noted that in all nations the demand for

TABLE I.1.--Percent Annual Growth[a] in Food Production, Population and Domestic Demand in Selected Asian Countries, 1952/76

Countries	Food Production	Population	Domestic Demand[b]
	Production failed to equal population growth		
Nepal	0.1	1.8	2.1
Bangladesh	1.6	3.5	n.a.
Indonesia	2.0	2.5	2.6
	Production failed to equal growth in domestic demand		
Burma	2.4	2.2	3.3
India	2.4	2.1	3.0
Pakistan	3.0	3.0	4.2
Philippines	3.2	3.2	4.2
	Production exceeded growth in domestic demand		
Sri Lanka	3.6	2.5	3.1
Korea	4.8	2.7	4.7
Malaysia	5.2	3.0	4.3
Thailand	5.3	3.1	4.6

Source: FAO (1974), pp. 53-4. Estimation of 1972-76 figures from personal correspondence with FAO officials.

[a]Exponential trend, 1952/76.

[b]Calculated on basis of growth of population and per capita income and estimates of income elasticity of farm value of demand in FAO (1971); total food, including fish.

n.a. = data not available.

food has grown at a more rapid rate than population. Demand for food in table I.1 has been estimated from population, per capita income, and the income elasticity of demand for food. The table shows that while the annual rate of population growth has been rather narrowly bracketed in the 1.8 percent to 3.5 percent range, trends in food production have varied to a far greater degree. Food production grew at an annual rate of only 0.1 percent in Nepal, while Thailand exhibited a growth rate of 5.3 percent.

The nations included in table I.1 may be divided into three categories: those whose food production did not keep pace with increases in population; those whose growth rate in food production exceeded population increases but did not keep up with demand; and those more fortunate nations whose food production expanded more rapidly than both population and demand. Increased food production has been rapid enough to keep up with demand in only four of the eleven nations examined here (Sri Lanka, Korea, Malaysia, Thailand). In the other seven, there has been an increased dependence on imports, a decrease in exports of food, or upward pressure on domestic prices.

How can we explain this wide variance in the rate of growth in food production in the twenty-five years since the Korean conflict? The answer to this seemingly simple and straightforward question is complex. The natural resource base of climate, soil, and topography sets definite limits on the ability of a nation to meet production goals. Man has erected a complex superstructure of political, social, and economic forces which importantly influence how these resources will be used.

Examples may be found in land tenure arrangements, policies pertaining to international trade, and price relationships between rice and fertilizer. Some nations have benefited very little from the new rice technology. Poor water control in the major river deltas, and rainfed terraced hills and plateaus set barriers to the adoption of new fertilizer-responsive varieties.

This brief review provides only a sketchy description of the intricate tapestry of Asian food and rice production performance. If we are to gain better insight into the forces regulating rice production trends within specific nations in order to provide policy guidelines, it is imperative that farm level data be gathered. Micro-level research for this report has been conducted in Indonesia, the Philippines, and India. These three countries were selected because they are amongst the most populous of Asian nations. Specific sites have been carefully chosen within each nation to reflect the widest possible range of factors influencing the adoption of technology and the way in which the induced changes spread among rural households.

A coastal village in Central Java, Indonesia represented areas of dense population and little technical improvement in rice culture. In essence, this is a benchmark site which may be classified as traditional. Within the Indonesian village, ownership of land and access to agricultural employment opportunities were considered by researchers to be the major determinants of the welfare of rural families. Two sites in the Philippines were chosen, one in coastal Laguna and the other in Central Luzon. Since the International Rice Research Institute (IRRI) is located in Los

Banos, Philippines, it is logical to assume that new rice technology might spread from this center. The Philippine sites may be thought of as typical of locales where MV and associated improvements in the use of agricultural chemicals and water control have been widely adopted by a significant proportion of farmers. Researchers felt that average farm size at the two sites in the Philippines would be similar to the Indonesian study area. Thus, if significant differences in the status of rural families were found it would then be attributable to technology and other man-imposed forces.

The Indian site of Chittoor District, however, was quite different. Here farm size was considerably larger, and farmers had not only adopted MV, but a significant proportion of farm operators either owned or rented four-wheeled tractors in the thirty to forty horse-power range. In addition, the village of the middle hill district of Nepal was selected to analyze factors relating to the adoption of new agricultural technology. In-depth interviews were conducted with farmers in this Nepalese village to determine what forces contributed to or inhibited their use of improved agricultural technology. The study sites were purposely selected to represent a continuum of agricultural technology and resource bases, and hopefully, a broad range of cultural and economic factors as well.

The AID "Poor Rural Household" contract was a collaborative effort between Michigan State University, Purdue University, and Cornell University. Michigan State research concentrated on West Africa, while the research thrust of Purdue centered on Brazil. Cornell research encompassed the Asian sites described above.

Objectives

In advance of the research each university agreed to a common set of objectives:

1. To compare and contrast production systems, use of time, participation in labor markets, and family income under different ecological and institutional environments and at different states of development in selected African, Asian, and Latin American countries.
2. To analyze sources of income and differences in income of poor rural households, including landowners, tenants and landless workers.
3. To analyze the rural labor market with respect to demand/supply behavior, efficiency of the labor market, and migration.
4. To analyze the barriers to the increased participation of landless workers in the development process.
5. To analyze the constraints to the adoption of new production technology.
6. To develop and test models to measure the impact of technical change on output, income, and employment of poor rural households.
7. To develop and test policy models for analysis of aggregate impacts of trade, taxation, and domestic agricultural policies.
8. To identify policy and institutional changes to increase the participation of the rural poor in, and their benefits from, the development process.

These objectives are broad and have many facets. The research conducted by Cornell University concentrated on various aspects of the first seven objectives; however, some observations are relevant to the eighth.

Since this document is lengthy, a short summary outline of the report has been provided as a guide to the overall organization of the paper, and to allow the reader to see how specific topics fit into the broader context of the report.

Section I develops a framework for analyzing the diffusion of agricultural technology and how this technology affects rural households. The ways in which variability in climate and soil bear on the appropriateness of technology for a specific locale are also examined. For example, shorter growing season varieties of rice may be appropriate only where soil quality and water control allow the practice of double cropping. The section also discusses input availability in the form of credit, transportation facilities, and such items as fuel or replacement parts for machinery as necessary adjuncts to improved cultural practices. Sociological forces cannot be ignored. The way in which a rice crop has been traditionally shared between landlord, tenant, and landless laborer may importantly affect the adoption of new varieties or mechancial harvesting equipment. The remaining portion of section I describes the specific study sites in detail. Since the research reported herein is based on farm-level data, a discussion of the procedure of selecting representative farms and the data obtained is included. In summary, section I presents a discussion of the factors which influence the spread of agricultural technology, as well as providing an assessment of the importance and operation of these factors in each of the study sites.

Section II details the patterns of household income in the Indonesian, Philippino, and Indian sites. Particular attention is given to income distribution among households with different assets--notably productive farm land. The degree to which household income is skewed influences the initiation of policies and the adoption of technology. Interclass differences in sources of income and levels of consumption are equally important to an understanding of the way in which household decisions are made. In general, section II provides a picture of the factors which regulate the level of income and its distribution in the three major study areas. Levels of income are related to the sequence of household decision making.

Section III centers on the measurement of the influence of technology on the economic well-being of families studied in the three survey sites. The section is divided into four sub-sections. In the first, the current level of agricultural efficiency is explored, while the next section looks more closely at patterns of technology adoption, including the kinds of technology tried and some interpretations of the reasons for adoption or rejection. The third sub-section discusses constraints to the adoption of new technology. Here a broader range of research findings than those from the three primary sites is presented. The analysis is enriched by a discussion of the perceptions of farmers in a Nepalese middle hill village, and examines the reasons for the reluctance on the part of farmers to adopt apparently superior innovations. The comprehensive literature describing the constraints to the adoption of new technology in various Asian nations has been abstracted to broaden the perspective concerning the observed barriers to the diffusion of improved technology. The final portion of section III deals with the impact of new technology on household income and the availability of employment. In short, section III looks at various facts of the adoption of new technology concluding with an assessment of the impact of differing levels of technology on two important indicators of welfare--income and employment.

Section IV deals with the way in which individual members of households allocate their time to various farm and non-farm activities. This involves the development of a clear understanding of the way in which rural labor markets operate within selected Asian villages. The most important forces influencing the way in which labor is allocated include the amount of land a family owns and the age and sex composition of household members. The "survival strategy" of landless households is discussed with particular attention to the role of women. The structure of labor markets influences the adoption of technology and also the way in which returns from increased production will be shared if the modernizing techniques are successful. Section IV presents evidence to show the degree to which tractor mechanization displaces labor and affects cropping patterns. The overall objective of the section is to provide a better understanding of how household decisions are made and labor markets operate in a variety of conditions, including differential levels of technical improvements.

The purpose of the last section is to synthesize overall research results. It is divided into two parts: major findings and policy implications. An attempt will be made to relate these findings to those of of other researchers. The focus is on providing policy makers with information which will allow them to assess the likely outcome of various strategies of development when account is taken of the barriers imposed by the natural resource base, and the economic, social, and political environments.

Policy Issues in the National Context

Insofar as the studies reviewed here relate solely to rural communities in Asia in which irrigated rice is the principal crop, the policy issues considered are those concerning the possibilities of adapting modern rice-growing systems to meet the needs of rural populations. The implications which changes in rice-growing technology may hold for the industrial and other non-agricultural sectors of Asian economies, as well as the implications for the fulfillment of the food requirements of these nations, will not be considered. The principal object is to examine the evidence about actual, and hence potential, effects upon the welfare of rural communities of changing rice-based agricultural production systems.

A Framework for Analyzing the Effects of Modern Rice-Growing Technology in Asia and for Deriving Policy Guidelines

In order to relate the results of the Cornell/AID studies of irrigated rice-growing areas in Indonesia (Central Java), the Philippines (Laguna and Central Luzon), and India (Chittoor District) to one another and to the broader literature covering rice growing in these and other Asian countries, it is necessary to establish a framework of analysis which embraces all developing Asian nations dependent on rice. It is fortunate that the recent work by Ishikawa (1978), combined with a large volume of literature published by the International Rice Research Institute (IRRI), suggests a suitable analytical framework which permits both the categorization of the diverse conditions and experiences in different rice-growing areas of Asia, and permits the identification of some common policy issues. This framework is based on the interaction of four influencing forces: the natural resource base, man-land ratios, availability of inputs, and market conditions.

Before amplifying the framework, it will be useful to briefly discuss the objectives of policies to improve rice production and the various classes of available technologies. These objectives will be sketched only in general terms, and no attempt will be made to indicate the various weights which should be attached to allow for inter-country differences. In view of the continuing increase in the rural population in Asia, what is looked for is technological and concommitant institutional changes which increase the acreage cultivated, insofar as this is still possible; increase output per hectare cultivated; increase employment and wages per hectare cultivated; and improve distribution of production and employment in order to benefit the poorest members of the rural community. It is axiomatic that such changes must be profitable for farm operators and landlords. And from the viewpoint of policy makers, it will be assumed that the changes should be socially progressive along the lines implied by the last objective.

Technology available for wet land rice culture may be divided into four categories:

<u>Biological Technology</u>

--In the form of new and improved varieties of plants this is the basic ingredient of the new rice technology in Asia. Due to increased yields, the primary effect is equivalent to increasing the cultivated area. It may also be described as land-augmenting with the consequence that it increases the demand for all those factors which are complementary with land except those required for tillage.

<u>Chemical Technology</u>

--In the form of inorganic fertilizers this typically increases yields and is land-augmenting.

--Insecticides are expected to increase yields and so are also land-augmenting. To the extent that they do not replace any traditional means of insect control they create a new demand for labor.

--In the form of herbicides this technology is likely to substitute for manual weed control and to be labor-saving.

<u>Mechanical Technology</u>

--Mobile power:

a. In the form of tractors and cultivating implements this technology applied to land already cultivated substitutes for labor and animal power. When used to bring into cultivation land which could not be worked by traditional methods, it creates demand for additional labor and all other factors complementary with land. This latter role, however, is a minor one, and the labor-saving effect may be assumed to be dominant.

b. In the form of harvesting equipment this technology substitutes for labor and animal power.

--Static power:

a. Threshing machines substitute for labor and possibly animal power.

b. Mechanical water pumps may displace labor and animal power, but where they permit the irrigation of new areas this form of technology increases the demand for all other factors. Where they facilitate a shift from single to multiple cropping systems their effect in increasing labor demand is considerable.

c. Augurs and conveyor belts substitute for labor and possibly animal power, although this form of technology is not widespread in rural Asia.

Organizational (Managerial) Technology

--This technology is significant with respect to "the way things are done"--that is, the way in which resources are combined and used--and it is intimately related to the stock of human capital. Changes in the way things are done may not require any new or additional resources, and may result from a process of learning-by-doing on the part of farmers, rather than from a formal investment in human capital through an educational system. Organizational changes may substitute for land (e.g., transplanting, rotations, and inter-cropping), or for labor and machinery (e.g., mulching and row cropping).

This classification of technologies is based upon new types of inputs and could certainly be expanded into a more elaborate and comprehensive listing. In addition, it should be observed that in some cases a major force for technological change is not the introduction of new inputs, but of new products; this, however, is not relevant in the present case. Nevertheless, the classification presented does demonstrate the extent to which any one broad class of input-embodied technological change may have diverse effects upon the markets for other factors, depending upon the situation into which it is introduced. This qualification is implicit with regard to many of the generalizations in later sections.

Analytical Framework. This framework should be useful in establishing hypotheses concerning the reasons for striking geographic differences in rice culture, such as fourfold differences in labor application per unit of land; two- to threefold differences in the yields achieved with modern varieties; differences in the multiple cropping index; and associated variations in the production techniques adopted.

Although a more complex schema could certainly be devised, the framework is elaborated here in terms of four superimposed classes of factors. The influence of these factors is in reality, interactive; and moreover, the classes are not wholly independent. In addition, it should be observed that the nature of the interaction between factors and their relative dominance will vary from location to location. The classes of factors considered are:

--Geographical, climatological, and pedological factors.

--Input availability, with particular reference to the present balance between human population and the land.

--Sociological factors, and in particular, the existence of pronounced class structures.

--Market conditions which influence the demand for agricultural products and the prices of inputs.

Geographical, Climatological, Pedological Factors. A major factor influencing rice cultivation in Asian countries is the latitude and associated climatic regime. In countries in relatively northerly latitudes, such as Japan (45°N to 30°N) and Northern China, the growing season is too short to permit two crops of rice. Here agricultural intensification has depended upon the substitution of more labor and capital intensive products (such as silk) for rice, or for the introduction of livestock and of minor non-rice crops as second crops. In spite of the highly intensive system of rice-based agriculture developed in Japan, the double cropping index there does not appear to have reached 150 (see table I.2).

Further south the growing season for rice is still too short to facilitate two crops of rice. Ishikawa (1978, p. 49) records rice cultivation over the last few decades in the Yangtse River Valley in China (32°N to 26°N) and indicates that the progress towards double cropping of any type (not only of rice followed by rice) was slow, given the short growing season of only 210 days. Under these circumstances mechanization of tillage, threshing, and water pumping played a critical role in facilitating double cropping when shorter maturing rice varieties became available.

Similarly, at the sites surveyed by IRRI (1975; 1978a) in Northern India (Uttar Pradesh) and the Pakistani Punjab, which lie between 25°N and 30°N, the dry season is too cool (and too dry) for a second rice crop to be grown. The dominant pattern on irrigated land there is for a wet season rice crop to be followed by wheat in the dry season (table I.3).

TABLE I.2.--Gross Agricultural Income per Hectare as Related to Double Cropping Index, Labor Use, and Fixed Capital Inputs Excluding Land: Selected Asian Countries

	(1) Gross Agr. income		(2) Double cropping index	(3) Labor input	(4) Total fixed capital excl. land	
	in local currency	paddy eqt unit ton		working day	in local currency	paddy eqt unit ton
Japan ('000 yen)						
National	214.2	5.76	139.3	494.7	255.0	6.86
1951 Tohoku	194.1	5.22	114.9	388.6	206.6	5.56
Kinki	292.4	7.87	163.6	649.7	513.9	13.83
National	303.2	6.06	131.1	529.6	458.5	9.16
1956 Tohoku	302.9	6.05	111.8	458.9	385.1	7.69
Kinki	498.3	9.95	163.3	663.0	715.8	14.30
National	395.0	7.21	133.4	523	568.8	10.42
1961 Tohoku	364.0	6.65	108.5	417	626.6	11.48
Kinki	528.0	9.64	151.7	639	900.7	16.50
Korea, South ('000 hwan) 1960	534.2	4.00	-	497.7	293.8	2.20
Taiwan ('000 NT$) 1964	42.7	8.52	-	469	14.4	2.86
China (yuan)						
East Central 1921-25	245.7	4.24	128.0	384.4	153.5	2.65
China, Mainland (yuan) 1957						
National average	370.5	2.87	-	240	111.8	0.86
Northwest, Inner Mongolia	283.5	2.19	-	120	-	-
Northeast	247.5	1.91	-	90	-	-
Central	441.0	3.41	-	270	-	-
Southern	576.0	4.45	-	465	-	-
India (Rs) 1956-57						
West Bengal	565.1	1.79	108.3	137[a]	1,014.4	3.21
Madras	471.5	1.39	-	186[a]	994.4	2.92
Punjab	552.0	1.79	131.4	109[b]	462.4	1.50
Bombay	171.2	0.34	113.9	56[c]	-	-

Source: Ishikawa (1978), p. 6.

[a]The figures relate to the sum of working days for crop production and animal husbandry.

[b]This is an estimated figure based on the survey findings that the number of man-days worked by a permanent farm worker in the year was 154 days for crop production and 111 days for tending of cattle.

[c]Refers only to the labor for crop productions.

TABLE I.3.--Cropping and Irrigation Characteristics in Sample Villages in Selected Areas in Asia, 1971/72

Location	Avg. Farm Size (ha)	Avg. rice area (ha)		Rice area irrigated (%)		Quality of irrigation[a]	Double-cropped rice area (%)
		Wet	Dry	Wet	Dry		
				India			
Uttar Pradesh							
Dhanpur-Vijaypur[b]	6.0	3.2	-	65	-	3	-
Tarna[b]	1.2	0.5	-	92	-	3	-
Barain[b]	1.2	0.7	-	31	-	4	-
Orissa							
Kandarpur	0.6	0.6	0.5	100	97	3	83
Korpada	0.6	0.6	0.5	98	100	3	83
Andhra Pradesh							
Pedapulleru	4.7	4.4	3.8	100	100	3	66
Mysore							
Gajanur	2.4	1.7	1.1	100	100	2	60
Hosahally	4.8	1.9	1.5	100	100	2	61
Ashoknagar	2.8	2.2	1.9	100	100	2	84
Tamil Nadu							
Kariyamangalam	4.1	1.4	0.8	100	100	2	61
Palvarthuvenran	2.0	1.3	1.2	100	100	3	91
Manmalai	1.8	0.7	0.6	100	100	2	89
				Indonesia			
Central Java							
Nganjat	0.5	0.5	0.5	100	100	1	100
Kahuman	0.6	0.6	0.6	100	100	1	100
Pluneng	0.5	0.5	0.5	100	100	1	100
East-West Java							
Sidomulyo	0.5	0.4	0.3	100	100	2	90
Cidahu	0.5	0.5	0.5	100	100	2	100
				West Malaysia			
Kelantan							
Salor	0.9	0.8	0.8	100	100	3	100
Meranti	1.0	0.9	0.9	94	94	3	100
				West Pakistan			
Punjab							
Aroopb	6.7	3.7	-	100	-	2	-
Maraliwalab	7.8	6.0	-	100	-	2	-

TABLE I.3.--cont.

Location	Avg. Farm Size (ha)	Avg. rice area (ha)		Rice area irrigated (%)		Quality of irri- gation[a]	Double-cropped rice area (%)
		Wet	Dry	Wet	Dry		
				Philippines			
Nueva Ecija							
San Nicolas	2.5	2.5	2.5	100	100	2	93
Malimba	3.1	3.1	3.1	100	100	3	92
Mahipon	3.8	3.8	0	0	0	5	0
Leyte							
Canipa	1.7	0.8	0.8	90	90	3	100
Marcos	1.5	0.4	0.4	99	99	3	100
Tab-ang	1.2	0.7	0.7	99	99	3	100
Davao							
Beynte Nuwebe	1.7	1.7	1.7	100	100	4	100
Sinayawan	2.2	1.9	1.9	100	100	4	100
Cotabato							
Bulucaon	2.0	1.8	2.0	100	100	3	100
Maluao	2.9	1.6	1.6	90	84	5	100
Capayuran:							
Christian	1.9	1.3	1.2	100	100	3	100
Muslims (Cabpangi)	3.9	1.4	1.3	100	100	5	95
				Thailand			
Suphan Buri							
Rai Rot	7.0	5.3	1.4	98	100	3	19
Nong Sarai	7.8	6.1	1.1	73	100	4	13
Sa Krachom	7.8	5.4	0	0	0	5	0

Source: IRRI (1978a), p. 9.

[a]1 = very good; 5 = poorly irrigated or wholly rainfed.

[b]Second crop is wheat.

Nearer to the Equator the length of the growing season for rice (or for other crops) is not restricted by temperature, and provided that water supplies and water control measures are adequate rice can be grown throughout the year. For countries in the latitudes $10^{o}S$ to $20^{o}N$, the multiple cropping index is typically high on irrigated land. Thus, as can be seen from table I.3, virtually all the land in the villages surveyed in Indonesia and much of the Philippines is double cropped under rice. In these areas systems, such as those reported by Ihalauw and Utami (1975) for Klaten, Central Java, have developed in which five crops of rice, or four crops of rice and one of tobacco, can be grown in 24 months. It is interesting and important to note that this level of cropping intensity was achieved without the aid of tractors, and with little mechanization other than sprayers and rotary weeders. Tractors had previously been used, but Ihalauw and Utami (1975) report that all had broken down by the survey date in 1971/2. Likewise, Ishikawa (1978, pp. 49-56) records that a similar pattern of crop intensification in Taiwan (at $23^{o}N$, but with a favorable climate) was not dependent upon mechanization, but that improved irrigation and drainage were the key developments enabling the potential of imported Japanese rice varieties to be fully exploited. Indeed, Ishikawa states that

> in the South Asian countries where growing of rice is physically possible all year round, and where the immediate target of multiple cropping is at a relatively low level, introduction of mechanical ploughing is not necessary; it tends to result, rather in an overall reduction of per year per hectare labour input. Leaving aside the issue of irrigation requirements, it is only mechanical threshers and dryers that tend to facilitate multiple cropping. . . . A complete system of mechanisation like that in present day Japan is certainly not necessary for multiple cropping elsewhere, since it even decreases the

> amount of per year per hectare labour input for total agricultural production. (Ishikawa 1978, p. 72.)

In addition to the factors already mentioned, it is evident that differences in altitude (given the latitude) and topography will influence the rice production system adopted in different areas. For example, farmers may be precluded by these factors from growing paddy rice and turn instead to upland rainfed rice. Another effect of topography is that it greatly influences the type of irrigation system which is adopted and the input requirements for the delivery of water to the fields. This is significant in explaining some of the variance in the data on labor input per crop per hectare (table I.4) seen by Ishikawa:

> The peculiarly large requirement for irrigation labour in Madras was due to the fact that irrigation there depended on wells and animal power. Similarly, irrigation in the deltaic fields using creek water usually required a large amount of labour as was the case in the Saga plain prior to 1922. . . . Ordinary gravity irrigation did not require such extensive labour input, even when water flow was regulated by traditional facilities. (Ishikawa 1978, p. 27.)

Presumably, mechanical pumps have been introduced in many places since the period discussed by Ishikawa. But to the extent that their adoption is not complete, major differences in labor required for irrigation may still exist between regions. This factor, however, will not assume great significance in the current study since, although labor input data have been collected in the Cornell/AID studies, it has not been recorded for irrigation or for dike repairs.

Finally, it is worth mentioning that differences in soil-type may play a significant role in explaining differences in the technology adopted, although they are not important in the current study. Heavy soils may not

TABLE I.4.--Paddy Rice Yields per Hectare as Related to Inputs of Labor, Animal Power, and Other Inputs: Selected Asian Countries

	(1) Paddy yield per ha	(2) Human labor input per ha	(3) Animal labor input per ha	(4) Material inputs per hectare other than labor	
				in local currency	in paddy equivalent unit
	m-ton	day	day		m-ton
Japan ('000 yen)					
National	4.249	255.6	18.0	56.01	1.955
1950 Tohoku	5.334	260.2	21.1	53.34	1.862
Kinki	4.486	295.0	16.5	44.86	1.566
National	5.067	229.1	14.4	79.03	1.546
1956 Tohoku	5.684	229.4	16.6	84.19	1.682
Kinki	4.481	233.9	15.7	83.50	1.668
National	5.798	190.0	6.0	100.33	1.605
1962 Tohoku	6.059	200.8	6.5	108.61	1.801
Kinki	5.285	188.4	7.4	103.13	1.710
Korea, South ('000 hwan)					
1960	3.271	139	12	90.17	0.674
Taiwan					
1926 Native rice	2.115	96[a]	[a]	128.23[a]	1.028[a]
Ponlai rice	2.313	110[a]	[a]	182.48[a]	1.182[a]
1967 Central Taiwan	5.1	113	-	-	-
1972 "	5.7	125	-	-	-
China (yuan)					
East Central 1921-25	2.559	145.8	38.8	-	-
Philippines: IRRI Surveys					
1966 Central Luzon-Laguna	2.2	60	-	-	-
Laguna	2.5	88	-	-	-
1974 Central Luzon-Laguna	2.2	82	-	-	-
1975 Laguna	3.5	105	-	-	-
India (Rs) 1956-57					
Madras Salem and Coimbatore	2.250	216.6	207.5	381.0	1.119
West Hoogly	1.800	132.9	89.3	70.4	0.222
Bengal Parganas	1.541	103.4	35.9	64.5	0.205

Source: Ishikawa (1978), p. 4.

[a]The figures include some man-days and input costs which should be attributed to animal work and its costs. This upward bias occurred due to the peculiar accounting methods described by Ishikawa, but the degree of the bias does not seem to be large.

be tillable by human or animal power, and the introduction of tractors and associated machinery may be a prerequisite for their cultivation.

Input Availability. It is accepted that a major determinant of both cropping intensity and production technology is the ratio of labor to cultivated land. The relationships anticipated and typically observed are that an increasing labor-to-land ratio (1) is associated with increases in cropping intensity; (2) favors the adoption of labor-intensive technology such as modern seed varieties, inorganic fertilizers, insecticides, and irrigation, and discourages the adoption of labor-substituting mechanical technologies; and (3) leads to the application of larger amounts of labor per hectare per crop.

Evidence of the first of these relationships is demonstrated in table I.3. It is shown that in those villages with high average farm size (low population-to-land ratio) the index of double cropping for rice is relatively low. The second relationship is less readily supported by simple partial (bivariate) analysis, but it is significant (see tables I.5 and I.6) that in Indonesia, where population pressure on the land is the most extreme among the study sites, tractor use is negligible despite a high multiple cropping index (table I.3). However, the multiplicity of factors affecting tractor use obscure the general picture, and the relationship between tractor use and population pressure is more readily revealed by the indirect route of relating it to farm size--on the assumption that family size per hectare decreases markedly with increasing farm size. Taking this approach in table I.7, the IRRI data clearly indicate that the proportion of small Asian rice-growing farms which employ tractors,

TABLE I.5.--Adoption of New Practices by Farmers who Have Tried Modern Varieties Selected Asian Countries, 1971-72

Location	Villages (no.)	Users before modern varieties (%)	First adopters (%) in[a]: Year of greatest adoption of modern varieties	First adopters (%) in[a]: Later year	Total users in survey year (%)
			Chemical Fertilizers		
India	12	55	34	11	100
Indonesia	5	76	20	4	99
Malaysia	2	72	10	18	94
Pakistan	2	80	2	0	76
Philippines	9	45	30	9	72
Thailand	2	57	17	8	69
All villages	32	58	26	9	88
			Insecticides		
India	12	34	34	14	80
Indonesia	5	71	23	5	93
Malaysia	2	48	10	0	49
Pakistan	2	48	4	6	58
Philippines	9	48	45	5	97
Thailand	2	61	15	6	71
All villages	32	47	31	8	83
			Tractors		
India	12	7	3	13	23
Indonesia	5	1	2	12	3
Malaysia	2	10	10	80	96
Pakistan	2	70	1	5	71
Philippines	9	27	19	14	58
Thailand	2	18	7	12	22
All villages	32	16	8	17	37
			Herbicides		
India	12	0	1	3	4
Indonesia	5	0	0	0	0
Malaysia	2	0	9	0	6
Pakistan	2	0	0	0	0
Philippines	9	33	31	9	66
Thailand	2	10	1	3	8
All villages	32	10	9	4	21

Source: IRRI (1978a), p. 29.

[a]Among those who were modern variety adopters in the wet season.

TABLE I.6.--Population and Arable Land Per Person Selected Asian Countries, 1976

	Arable Hectarage 1000 ha	Population thousands	% in Agric.	Pop./ha	Ag. Pop/ha
Indonesia	14,168	139,635	61.9	9.85	6.1
Philippines	5,200	43,468	48.9	8.36	4.1
India	164,800	628,834	66.0	3.81	2.5
Korea, Rep.	2,060	35,340	49.4	17.16	8.5
Thailand	15,750	43,490	77.2	2.76	2.1
Japan	4,415	112,770	14.0	25.54	3.6
Bangladesh	9,180	75,529	84.9	8.23	7.0
Pakistan	19,250	72,859	55.6	3.78	2.1
Sri Lanka	895	14,282	54.1	15.96	8.6
Nepal	2,010	12,877	93.1	6.40	5.9
Malaysia	3,139	12,454	50.9	3.97	2.0
China	128,570	852,565	63.1	6.63	4.2

Source: FAO (1977).

TABLE I.7.--Use of Specified Practices and Farm Size, 1971-72, Selected Asian Countries

	Farms (%) using		
	less 1 ha	1-3 ha	over 3 ha
Modern varieties			
Wet	84	86	93
Dry	89	91	89
Fertilizer			
Wet	76	75	82
Dry	84	83	85
Insecticide	79	81	83
Herbicide	6	20	29
Hand weeding	82	83	87
Rotary weeding	3	20	37
Tractors	13	41	57
Mechanical thresher	36	43	63

Source: IRRI (1978a), p. 32.

rotary weeders, and mechanical threshers is appreciably less than that for large farms.

As to evidence about the third relationship, between labor use per hectare and the population-to-land ratio, there is no readily available overview data for the IRRI study villages referred to in tables I.3-I.7. In all probability this lack reflects the considerable difficulties in adequately collecting labor-use data and of finding a suitable way of reducing these to a common base to permit ready inter-regional comparison. Data will be presented for the Cornell/AID studies which strongly support the third relationship.

In discussing regional differences in resource availability, it is important to recognize that there exist major regional differences in the potential of the rice varieties available. Work on developing modern varieties has usually been concentrated at specific locations, and the varieties produced have tended to be best adapted to those locations. This is true for the Philippines where, as can be seen from table I.8, adoption of modern varieties is higher there than in any other country included in the IRRI survey. Indeed, adoption was virtually complete by 1970 in the Philippine villages surveyed by both IRRI (1978a) and Ranade (1977); this explains the absence from table I.9 of any comparison for the Philippines of the yield ratio of modern to local varieties. In other countries less research has been devoted to the production of locally suited varieties. This is evidently so for Indonesia, where in the 1971/72 wet season, as shown in table I.9, modern varieties only outyielded local ones by 10 percent. With a margin as small as this, it is perhaps not sur-

TABLE I.8.--Proportion of Total Rice Area Planted to Modern Varieties, Asian Countries, 1967/77

Country	Proportion of total area in modern varieties (%)									
	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77
South Asia	3.8	6.4	9.9	12.9	17.2	20.6	24.3			
India	4.9	7.3	11.3	14.5	19.3	22.1	25.6	28.5	32.3	35.6
Bangladesh	0.7	1.6	2.6	4.6	6.7	11.1	15.7	14.9	15.0	13.5
Nepal	--	3.7	4.2	5.7	4.5	14.8	15.8	18.0	17.2	17.6
Pakistan	0.3	19.8	30.9	36.6	50.0	43.7	43.2	39.3	38.9	39.8
Sri Lanka	--	1.2	4.9	5.0	12.0	42.7	54.8	51.7	63.0	NA
Southeast Asia	3.2	7.2	10.0	12.6	15.7	20.0	25.3			
Burma	0.1	3.5	3.1	4.0	3.9	4.4	5.1	6.2	6.4	7.0
Indonesia	--	2.5	10.4	11.1	16.0	24.4	36.9	40.4	31.0	41.0
Laos	0.1	0.3	0.3	8.1	4.5	7.5	7.5	NA	NA	NA
Malaysia (West)	20.6	20.1	26.4	30.9	35.8	37.1	36.7	35.7	37.4	NA
Philippines	21.2	40.6	43.5	50.3	56.3	54.0	63.3	64.0	64.4	68.1
Thailand	--	--	0.04	0.4	1.3	4.2	5.0	5.5	7.1	11.3
Vietnam (South)	0.02	1.7	8.4	20.0	25.7	30.9	31.4	NR	NR	NR
Total Asia	3.6	6.7	10.0	12.8	16.7	20.4	24.7			

Source: Dalrymple (1978), p. 125.

TABLE I.9.--Average Yield and Income from Modern Rice Varieties (MV) and Local Varieties (LV) Compared in Villages in 9 Areas in Asia, 1971/72

	Yield (t/ha)			Income (US$/ha)[a]			Rice area in MV
	MV	LV	MV/LV	MV	LV	MV/LV	(%)
				Wet season			
India							
Varanasi, U. Pradesh	3.5	1.2	2.9	211	94	2.2	46
Cuttack, Orissa	3.0	2.3	1.3	274	215	1.3	15
West Godavari, A. Pradesh	4.1	3.1	1.3	320	259	1.2	9
Shimoga, Mysore	5.2	2.8	1.9	464	287	1.6	77
N. Arcot, Tamil Nadu	4.9	3.0	1.6	425	288	1.5	58
Indonesia							
Klaten, Central Java	5.4	4.9	1.1	304	334	0.9	66
Subang, West Java	3.2	3.0	1.1	126	128	1.0	50
Pakistan							
Gujranwala, Punjab	2.8	1.8	1.6	69	72	0.9	44
Thailand							
Don Chedi, Suphan Buri	2.5	1.7	1.5	96	63	2.9	22
				Dry Season			
India							
Cuttack, Orissa	4.0	2.9	1.4	345	266	1.3	92
Pedapulleru, A. Pradesh	5.4	2.4	2.3	406	178	2.3	44
N. Arcot, Tamil Nadu	5.2	3.5	1.5	458	393	1.2	82
Indonesia							
Klaten, Central Java	6.2	5.2	1.2	352	352	1.0	58
Subang, West Java	3.9	3.0	1.3	157	130	1.2	45

Source: IRRI (1978a), p. 22.

[a]Gross returns less fertilizer cost.

prising that in the face of certain problems with modern varieties, the Javanese villagers studied by Hart (1978) had abandoned modern varieties by 1976. It is particularly important that appropriate MV for Indonesia be developed, since on Java there is intense land pressure and a great need for a highly productive agricultural system.

Sociological Factors. The argument will be developed in this report that the existence of a well-defined class society, and inequality in land ownership and access to land and other productive assets, have a marked influence upon the pattern of adoption of new technology and also lead to changes in local economic institutions governing labor exchange and land rental. More specifically, it appears that the more stratified and inegalitarian the society, the more likely it is that (1) labor displacing technology will be adopted despite the existence of ample supplies of labor; (2) institutions rooted in a sense of community which formerly ensured poor families a share of the harvest will be replaced by impersonal institutions which increase the share of landowners and farm operators--moreover, it is the new technology which provides the impetus for this change; and (3) that differences will occur in the technology adopted and performance achieved by large as opposed to small farmers. The basis for such arguments has been extensively developed by Griffin (1974), but some new insights into these issues are revealed by the data reviewed here. Certainly it becomes evident that some account needs to be taken of sociological factors to explain interregional differences in the adopted system of rice farming.

Market Conditions. No framework would be complete if it did not take account of the influence of market forces in explaining interregional differences in systems of rice growing. One interesting set of data collected by the IRRI survey, and reproduced in table I.10, is for the ratio of the price of modern to local rice varieties. As can be seen, there was a fairly wide range in this ratio, which was lowest (least favorable for modern varieties) in West Pakistan with a value of 0.6, and highest, 1.3, in Leyte, Philippines. Theory would suggest, especially in view of the higher cash input costs associated with the growing of modern varieties, that there should be a positive relationship between this price ratio and the area planted to modern varieties. Inspection of the data in table I.10 suggests that this is the case, particularly in the wet season, and multiple regression results obtained by Anden-Lacsina and Barker (1978) appear to confirm this.

Similarly, the IRRI survey led to the collection of a data series (presented in table I.10) on the fertilizer-to-paddy price in all the survey villages. This ratio exhibits a large range of variation, from a low of 1.7 in Nueva Ecija in the Philippines, to 6.7 at Sa Krachom in Thailand. Statistical tests were undertaken by David (1978) to determine the relationship between the fertilizer-to-paddy price ratio and the level of fertilizer application in the respective villages, and, as might be expected, a highly significant inverse relationship was found to exist. One might also expect that the adoption of modern rice varieties is inversely related to the fertilizer-to-paddy price ratio, although no results are reported to confirm this.

Among input costs it is not only the fertilizer price which varies between areas. Wages for labor may also vary, not solely as a function

TABLE I.10.--Price Ratio Variables and the Proportional Rice Acreage under Modern Varieties, 1971/72

	Price Ratio Modern to Local Varieties[a]	Ratio of Price of Nitrogen to Price of Paddy[b]	Area Planted to Modern Varieties (%)[a]	
			Wet Season	Dry Season
		India		
Uttar Pradesh				
Dhanpur-Vijaypur	0.7	4.0	73	---
Tarna	0.8	4.1	95	---
Barain	---	4.1	---	---
Orissa				
Kandarpur	1.0	3.0	15	97
Korpada	1.0	3.4	15	89
Andhra Pradesh				
Pedapulleru	0.9	3.4	9	44
Mysore				
Gajanur	1.0	2.8	88	97
Hosahally	0.9	3.0	88	100
Ashoknagar	1.0	2.9	62	100
Tamil Nadu				
Kariyamangalam	0.8	2.8	50	100
Palvarthuvenran	0.8	3.0	49	44
Manmalai	0.8	2.9	70	86
		Indonesia		
Central Java				
Nganjat	0.8	2.5	39	63
Kahuman	0.8	2.5	66	12
Pluneng	0.9	2.8	81	89
East-West Java				
Sidomulyo	0.9	4.0	97	94
Cidahu	0.9	3.8	26	45
		West Malaysia		
Kelantan				
Salor	1.0	3.8	22	89
Meranti	1.0	3.8	32	67
		West Pakistan		
Punjab				
Aroop	0.6	4.7	40	---
Maraliwala	0.6	4.2	49	---

TABLE I.10.--cont.

	Price Ratio Modern to Local Varieties[a]	Ratio of Price of Nitrogen to Price of Paddy[b]	Area Planted to Modern Varieties (%)[a]	
			Wet Season	Dry Season
		Philippines		
Nueva Ecija				
San Nicolas	0.9	1.7	100	100
Malimba	0.9	1.7	95	98
Mahipon		1.7		
Leyte				
Canipa	1.3	2.2	97	100
Marcos	1.3	2.2	100	100
Tab-ang	1.3	2.2	100	100
Davao				
Beynte Nuwebe	1.0	2.8	100	100
Sinayawan	1.0	2.8	100	100
Cotabato				
Bulucaon	0.8	3.4	100	100
Maluao	---	3.4		
Capayuran	0.9	3.5	100	100
Cabpangi	0.9	3.5	82	100
		Thailand		
Suphan Buri				
Rai Rot	1.0	6.4	41	96
Nong Sarai	1.1	6.5	21	96
Sa Krachom	---	6.7	---	---

[a]Source: IRRI (1978a), pp. 32-33.

[b]Source: IRRI (1978a), p. 75.

of the size of labor force, but also as a function of the opportunity cost of labor in non-agricultural employment. This is obvious when reference is made to Japan, an extreme case among Asian rice-growing countries. Japan has a very high ratio of population to arable land, but because of strong labor demand outside agriculture wage rates are also high. This has had the effect of inducing mechanization to save labor in agriculture.

To a large extent, the observed differences in fertilizer price throughout Asia are a function of differences in the efficiency of operation in input markets and distance from ports and fertilizer plants. However, effective, as opposed to listed prices may differ widely because of imperfections in credit markets. Where credit is expensive the effective price of inputs may be high to farmers relying on it to purchase inputs. Parthasarthy (1975) records that in Pedapulleru in Andhra Pradesh, the credit cooperative was controlled by high caste members of the village, and consequently institutional credit was denied to most tenant farmers, who were then forced to turn to higher cost sources of credit, thus increasing the cost of the new technology to them.

Finally, in considering market factors mention should be made of relative prices for alternative agricultural products. In some areas there may be no important alternative to rice, in which case economic pressures will be reflected in a high proportion of the total arable acreage under rice in both wet and dry seasons. In other places strong markets may exist for alternative crops or land-using livestock enterprises, such as for sugar in parts of India, and in these cases it may be expected that a significant proportion of the arable acreage will be devoted to these alternatives.

The Policy Issues

The two main relevant areas of policy choice relate to the level and type of involvement of governmental and international agencies in creating new technology to add to the stock available for adoption, and in directing the adoption of the technology which is available. In the current report emphasis will be almost wholly on issues in the second category, since all the research reported relates to the impact at the farm and village level of the adoption of new rice varieties and associated technology. Ideally perhaps, questions about the optimal scale and nature of intervention by public institutions should be based upon formal identification of divergences between social and private returns in Asian rice production, or assessment of whether the social and private returns could be significantly increased by some form of policy action; as well as upon some analysis of whether the incremental social returns justify the costs of the policy action. However, no aggregate level analysis or formal social benefit/cost analysis has been conducted which could resolve the issues in these ways, but it will be accepted as an article of faith that the justification for policy action does exist. More specifically, it is accepted that policy action is desirable to accelerate the rate of adoption of new technology in Asian rice growing areas, but as a corollary, this action should be pursued with regard for the distributional consequences of the growth of output which results. In fact, the major concern of this report lies with the corollary, since the research reported is best suited to the examination of distributional issues. Thus the specific issues of policy interest which will be addressed include:

--What differences are there in the technological packages which are appropriate for different areas, and what determines these?

--What are the effects of the observed technological changes upon the returns to specific factors of production and especially to different groups in society?

--What are the observed and potential effects of technology on the demand for labor?

--How is the impact of technological change modified by specific social and economic institutions; and are there particular types of institutions which may lead to socially desirable or undesirable consequences of technological change?

--Does the technological change observed lead to changes in social and economic institutions, particularly in the land and labor markets?

--What problems exist for poor and landless families in rural Asia within the context of changing rice technology, and how can the adoption of such technology be managed to minimize these?

The balance of this section will be devoted to a description of the study sites and methodology employed. Subsequent sections will address these six policy issues.

Characteristics of the Study Areas

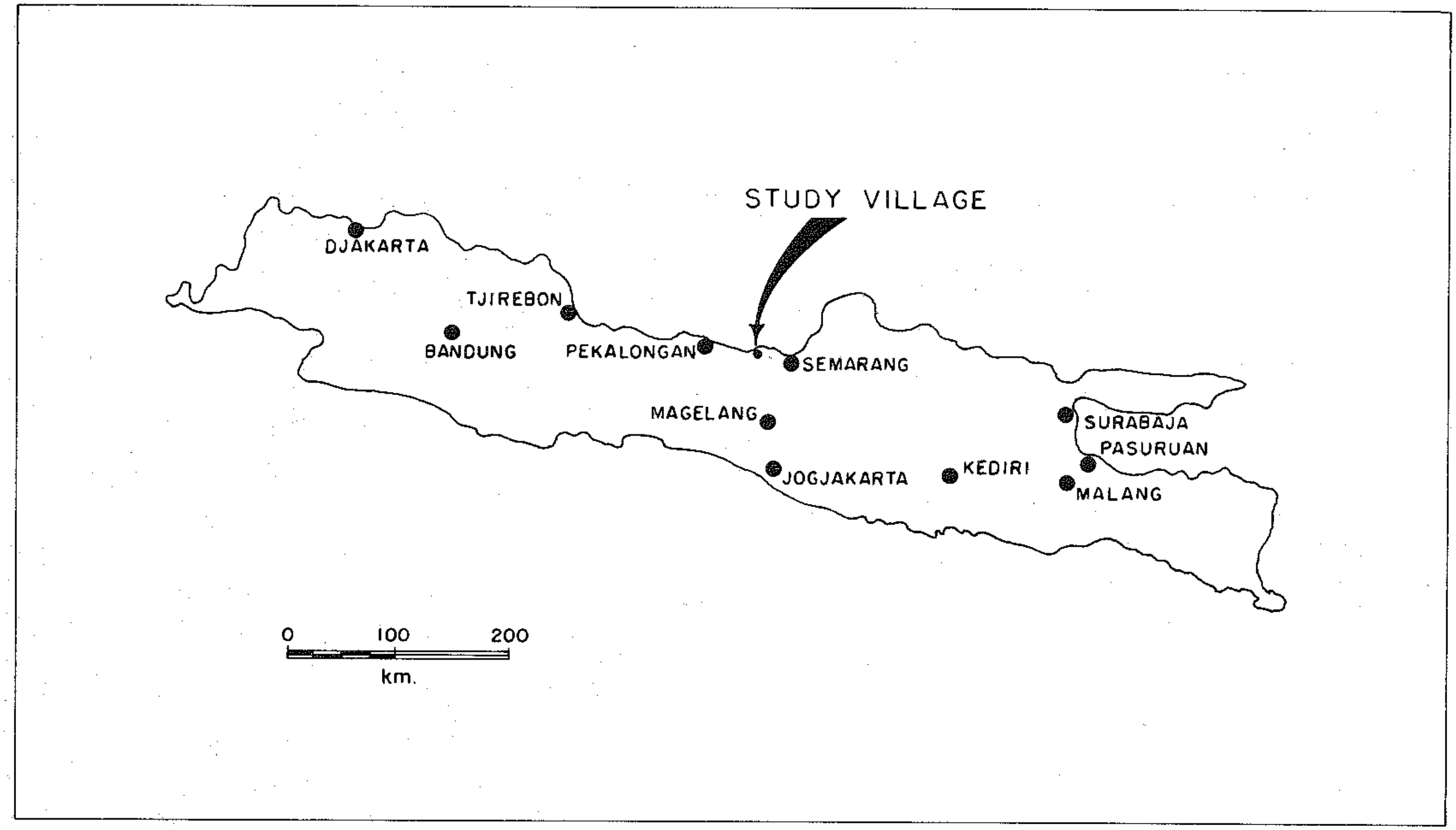
Location

Village A, Central Java, Indonesia. Hart's study was undertaken in one village only. For the purposes of this study the Javanese site will be referred to as Village A. This village is situated on the northern lowland plain (7°S, 100°E), in the Province and Regency of Kendal, about 28 kilometers west of the port city of Semarang (figure I.1). Despite being relatively close to Semarang and only 2.5 kilometers from the local town, the village is isolated. The roads are poor and can only be traversed by foot in the wet season; "even in dry periods, however, very little traffic enters or leaves the village, with the exception of an occasional ox-cart, bicycle, or motorcycle" (Hart, 1978, p. 87). Because it is a coastal village the opportunity exists for fishing as a secondary economic activity to the principal enterprise of rice production.

Laguna and Central Luzon, Philippines. The study conducted by Ranade covered two sets of data in the Philippines. Ranade selected three villages bordering Laguna de Bay (these had been surveyed earlier) to provide one set, and adopted the IRRI "Loop Survey" in Central Luzon for the other (see figure I.2).

Laguna de Bay lies to the south of Manila and is the largest lake in the Philippines. The three study villages there, Binan, Cabuyao, and

FIGURE I.I. LOCATION OF THE STUDY VILLAGE IN JAVA, INDONESIA



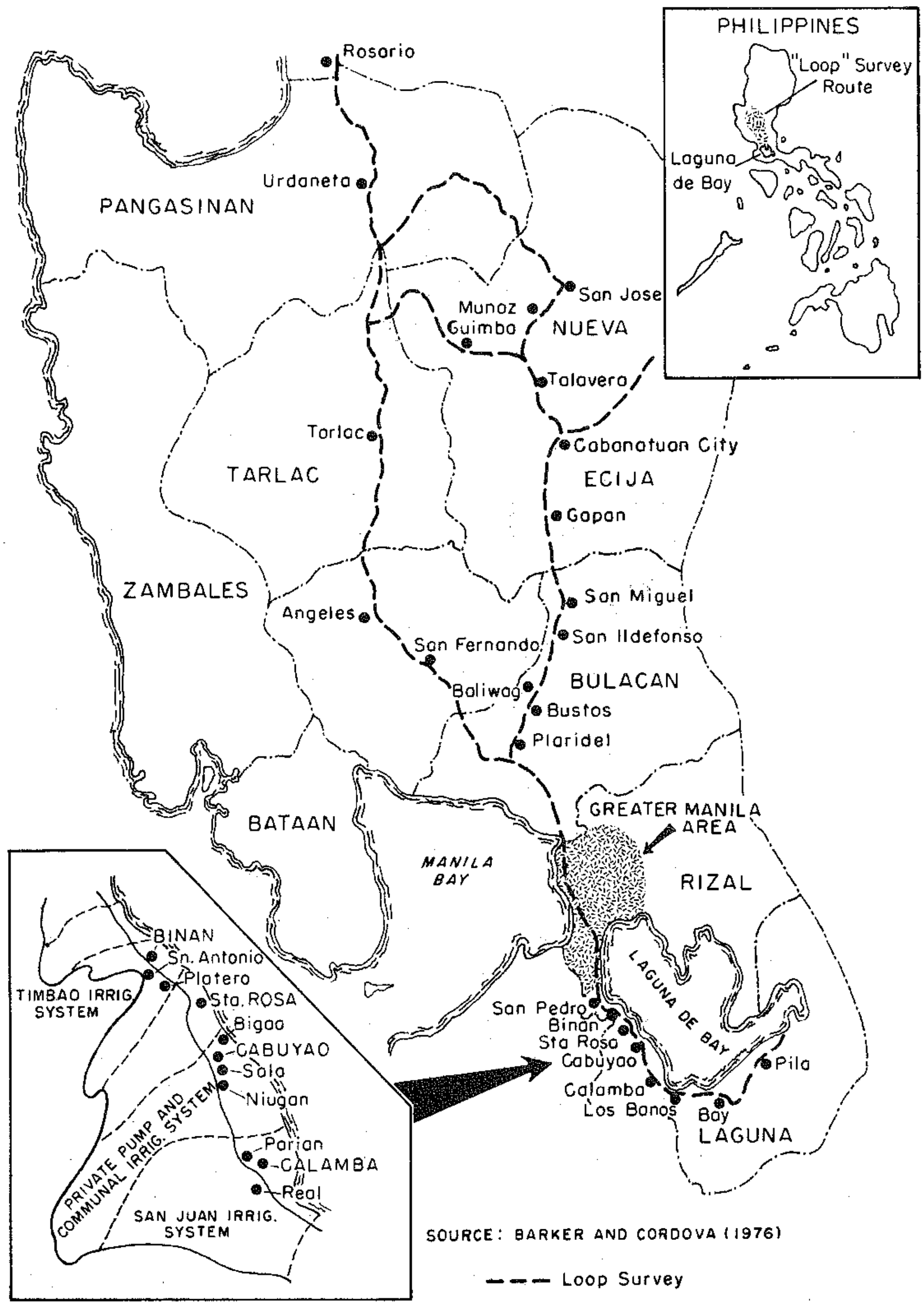


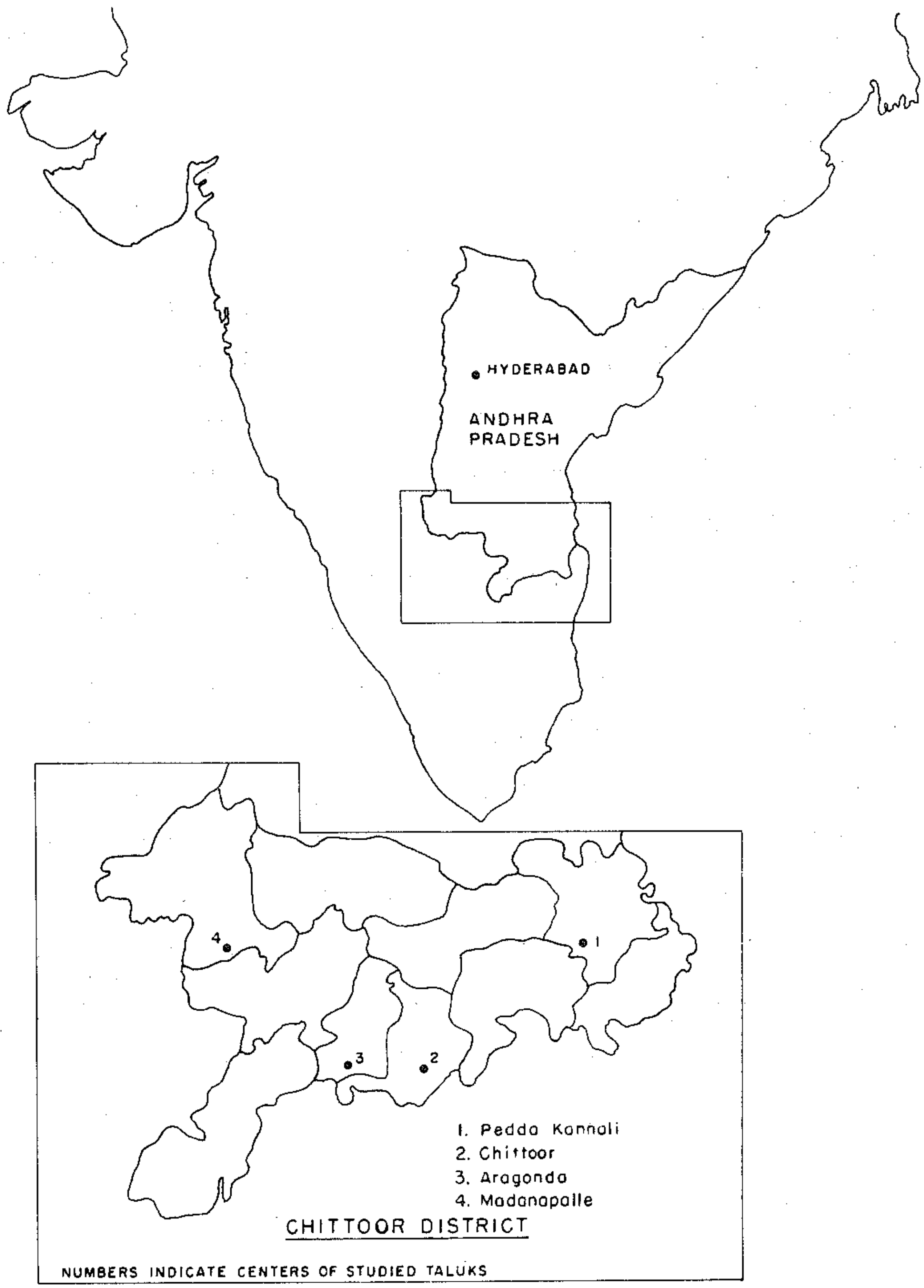
FIGURE I.2. MAPS SHOWING THE MUNICIPALITIES OF BINAN, CABUYAO AND CALAMBA AT LAGUNA AND THE LOOP SURVEY ROUTE FOR THE CENTRAL LUZON-LAGUNA SURVEY, PHILIPPINES

Calamba lie along the western fringe of the lake at approximately 14°N and 121°E. The area has a history of settlement dating back to the early Spanish period, and because of its good transport links via sea and lake it developed as a rice supply area for Manila long before Central Luzon came to adopt a similar role.

The Central Luzon survey does not cover villages; rather, data were collected for 145 holdings along the "loop road." The road passes through six Central Luzon provinces--Laguna, Bulacan, Nueva Ecija, Pangasinan, Tarlac, and Pampanga--and the surveyed holdings are dotted along 800 kilometers of the "loop road." The holdings were selected by IRRI with reference to kilometer posts; holdings chosen came to within 25 meters of the road and grew only rice.

Chittoor District, India. Doraswamy's study took him back to his home district of Chittoor in Andhra Pradesh. It is a fairly large district with a population of about 2.3 million in 1971. The town of Chittoor is located at the center of the district at approximately 13°N and 70°E. The survey was conducted at four clusters of villages in four of the taluks (subdivisions) of the district: Chittoor, Madanapalle, Pedda Kannali, and Aragonda (figure I.3). Topographically the district is a plain rising some 300 feet above sea level and broken in places by hills. Though present in all of the study taluks except Pedda Kannali, these hills do not have a significant impact upon the areas studied.

FIGURE I.3. MAP SHOWING SURVEY AREAS (TALUKS) IN CHITTOOR DISTRICT, ANDHRA PRADESH, INDIA



Ecological and Agro-Climatic Factors

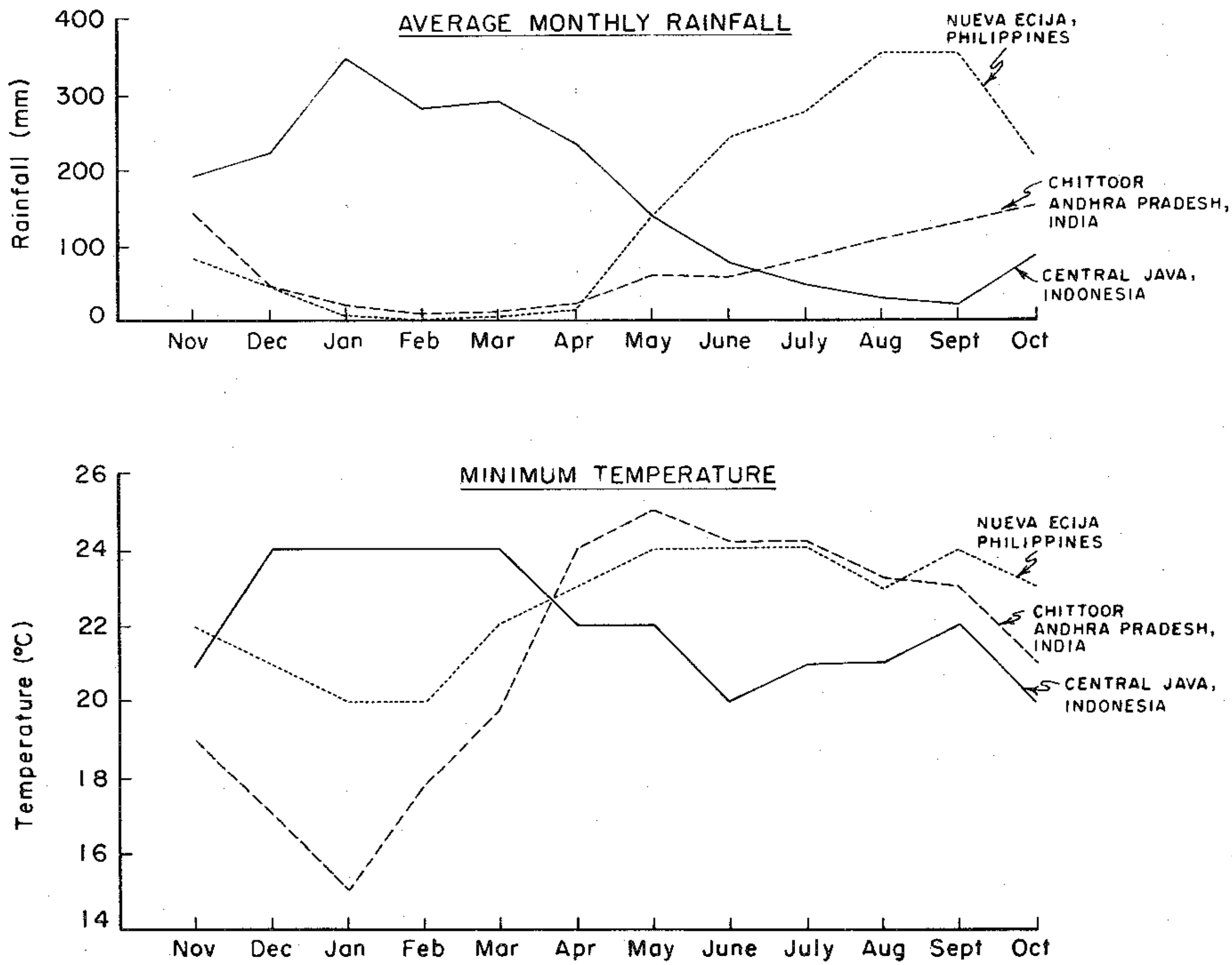
Village A, Central Java, Indonesia. The climate in this area is extremely favorable for rice production, as well as for sugar, although the latter is not grown in the village. As can be seen from figure I.4, a large amount of precipitation falls in the wet season (from November to April). In an average year there is also a significant amount of rainfall in May and June, marking the beginning of the dry season. The temperature regime is also favorable, remaining relatively stable throughout the year, with average minimum temperatures in the 20-24° C range.

The land controlled by the village amounts to 260 hectares (for a population of 2,149 in May 1974) plus 20 hectares of brackish water fishponds. Of the 260 hectares, 200 are wet rice fields, 39 hectares are houseplots and surrounding gardens, and the remaining 21 hectares are divided between a small area of dry land used for vegetable cultivation, and village land (school, mosque, cemetery, and village roads).

As is the case on much of the north coast, the main irrigation problems have to do with drainage. The study village is part of a well-established irrigation scheme, and irrigation facilities are reasonably comprehensive. Some 60 percent (121.4 hectares) of the rice fields are irrigated, and though part of the rainfed area yields two rice crops a year, water problems in the area near the coast are such that only one rice crop a year can be grown.

Laguna and Central Luzon, Philippines. Temperature and rainfall conditions in this area are almost exactly the same as those in Central Java (see figure I.4), except that the wet and dry seasons are reversed,

FIGURE I.4. CLIMATIC PATTERNS IN THE STUDY AREAS



SOURCES: IRRI 1975, pp 151, 267; CHITTOOR DISTRICT HANDBOOK OF STATISTICS, pp 72, 73, 76-78.

the former running from June to November. Conditions in both Laguna and Central Luzon are therefore highly favorable for rice cultivation. As far as land and water supply characteristics are concerned, it is not possible to generalize about the 145 sites in the "Loop Survey," hence no specific reference will be made to these agro-ecological factors in this study area.

The relevant information about the Laguna survey villages is not as complete as that reported for Village A, since no village or barrio level data were collected. Land areas for the barrios or their populations are unknown; nor is the pattern of use of controlled land known in the detail reported for Village A. Instead, building upon earlier sample surveys of farmers in the three areas, 114 farms (81 of which had dry season crops in 1971) were surveyed in the 1970 wet season. Thirty of the surveyed farms were in Binan, 38 in Cabuyao, and 46 in Calamba.

There are, however, significant agro-ecological differences between the three barrios, and they were in fact selected for this reason. In Cabuyao water is available all year round and is supplied by low-lift pumps. In contrast, in Binan and Calamba irrigation is entirely gravity fed, but this operates year round only in Calamba. In Binan there is no irrigation water in the dry season (although, as with the other barrios, all farms are irrigated in the wet season), which greatly restricts the cropping possibilities there. This difference in agricultural potential is reflected in the average farm size in the three samples--3.2 hectares for Binan against 1.8 and 1.7 hectares for Cabuyao and Calamba, respectively.

Chittoor District, India. The agricultural conditions in this study area are markedly different from those in the two areas just reported. As can be seen from figure I.4, there are significant climatic differences in that much lower temperatures are experienced in the dry season (December to May), and appreciably lower rainfall is expected during the year as a whole, and in the wet season especially. The main consequence of the latter observation, coupled with the facts that the area is not a low lying basin and there are no major rivers, is that irrigation is not as widespread as in Central Java, and Laguna and Central Luzon. The many minor rivers in the area do permit some irrigation in the wet season, but most do not flow in the dry season; thus wells are the primary source of irrigation and tanks constitute a secondary source. Of the 622,000 cultivated hectares in Chittoor District in 1972/73 (475,000 sown and 147,000 fallowed), 161,000--26 percent--were irrigated in the wet season. Irrigation enabled 40 percent of the area to be cultivated in the dry season.

From the data presented in table I.11, it would appear that the areas sampled are not entirely representative of the District as a whole, in that the proportion of land irrigated in all four samples is appreciably higher than the District average. Indeed, in Madanapalle, taking the two growing seasons together, approximately 70 percent of the sample area is irrigated, while in the other samples irrigation lies between 50 and 60 percent.

In addition to the variations in topography and irrigation type and potential within the District and between the study areas, there are also significant differences in soil type. At Pedda Kannali the predominant

TABLE I.11.--Cropping Patterns in Chittoor District, India, 1976

	Madanapalle		Pedda Kannali		Chittoor		Aragonda	
	(acres)	(%)	(acres)	(%)	(acres)	(%)	(acres)	(%)
Crops on Wet Land								
Irrigated crops								
Traditional paddy	7.8	2.0	98.6	10.9	29.2	6.7	18.1	4.5
MV paddy	155.3	39.6	90.3	10.0	17.8	4.1	25.2	6.3
Other food grains	22.8	5.8	47.8	5.3	5.0	1.2	3.2	0.8
Seed bajra/jowar	46.9	11.9	63.8	7.1	--	--	--	--
Sugar cane	8.4	2.1	--	--	177.1	40.8	184.7	46.4
Vegetables	34.4	8.8	1.6	0.2	3.4	0.8	5.0	1.3
Plantains/betals	--	--	--	--	0.7	0.2	1.2	0.3
Groundnut	--	--	199.8	22.2	--	--	--	--
Unirrigated crops on wetland								
Groundnut	--	--	--	--	2.6	0.6	6.2	1.6
Green fodder	0.5	0.1	--	--	--	--	--	--
Perennial crops	--	--	0.8	0.1	24.0	5.5	17.8	4.5
Unused wet land	44.4	11.3	398.0	44.2	30.9	7.1	18.4	4.6
Total wet land	320.5	81.6	900.7	100.0	290.7	67.0	279.8	70.2
Crops on Dry Land								
Groundnut	58.3	14.8	na	na	103.1	23.8	50.7	12.7
Green fodder	3.8	1.0	na	na	--	--	--	--
Perennial crops	0.5	0.1	na	na	36.4	8.4	24.7	6.2
Unused dry land	9.5	2.4	na	na	3.7	0.9	43.1	10.8
Total dry land	72.1	18.4	na	na	143.2	33.0	118.5	29.8
Total Acreage	392.6	100.0	900.7	100.0	433.9	100.0	398.3	100.0
No. of Farms	25		25		26		23	
Avg. Farm Size[a]	7.85		18.01		8.34		8.66	
Multiple Cropping Index	1.73		1.12		1.84		1.69	
Percentage of Crop Acreage irrigated	70.2		55.7		53.7		59.6	

Source: Doraswamy (1979).

[a]The acreage figures shown are the aggregates for both wet and dry seasons, thus each farm's acreage is counted twice.

soils are sandy loams, which explains the importance of groundnut production in this locale. At Chittoor and Aragonda the areas of red clay soils are well suited to sugar cane which is the principal crop. Only in the Madanapalle sample is rice the major crop, with modern varieties dominant, although at Pedda Kannali rice is only slightly less important than groundnut. It is this considerable variety of crops and cropping patterns which constitutes the major difference between the Chittoor study area and those in Central Java and the Philippines.

The Socio-Political System

Village A, Central Java, Indonesia. The village has a monolothic and paternalistic structure of government dominated by a few leading families. These include the major landowners, some of whom have achieved that position as a consequence of the privileges attendant upon their being government officials, for one of the benefits of public office is the bengkok land which is granted as a perquisite. In Village A, some 32.5 hectares of such land were allocated to 14 government officials in holdings ranging from 9.4 hectares (the headman), to 4.6 hectares (the secretary), and 0.975 hectares (the irrigation officials). Given that the average size of an operated holding in the village is only 0.79 hectares, it is evident that the holding of public office is a major factor determining economic status.

It is also important to note that the village headman, who has held that position since 1945, had forbidden the sale of land to outsiders and strongly discouraged in-migration. This had the effect of raising the average asset base per household in the village to a level slightly above that of other Central Javanese villages, although in most other respects Village A is fairly typical of villages in the area.

Laguna and Central Luzon, Philippines. A major land reform which encompasses the two study sites in Laguna and Central Luzon has been carried out since 1963 (this is fairly fully described in Mangahas et al. 1976). The major steps in this reform took place as follows:

1. In 1963, R.A. 3844 called for the replacement of existing share-tenancies by leases, and all share-tenants in designated land reform districts were supposed to have automatically become leasees at prescribed rates of rental. In the same year the maximum retention limit for landholdings was set at 75 hectares.
2. In 1971, the maximum retention limit for holdings was reduced to 24 hectares, and R.A. 6389 was enacted with provisions to accelerate the replacement of share-tenancies.
3. In 1972, Presidential Decree 21 declared all rice and corn growing lands in the entire country to be land reform areas. More radically, Presidential Decree 27 provided for the conversion of all tenants and lessee farmers into amortizing owners, who after a 15-year amortization payment scheme would completely own their land. In the same year, the retention ceiling for landholdings was reduced to 7 hectares.

This reform dramatically affected the economic power of dominant socio-political groups over agriculture in the study areas; it has had more effect in Central Luzon than in Laguna de Bay. Prior to the land reform, farms in Laguna were of a moderate size ranging from 10 to 20 hectares. They were operated on a landlord-tenant basis with a strong patron-client relationship between the landlord and a small number of tenant families. Central Luzon developed later and in a distinctly different manner. Huge estates, often over 1000 hectares, evolved as a result of purchases of crown and undeveloped land, and

> until the late nineteenth century, most areas of Central Luzon were covered by jungles and large haciendas were primarily engaged in cattle ranching. . . . Subsequently, the haciendas located in the lowland areas developed a system of rice monoculture . . . while those located in upland areas were converted into sugar plantations. . . . In the large haciendas with several hundreds and thousands of tenants, the landlord-tenant relationship was inevitably less paternalistic than in the Coastal Region. Typically hacienda owners lived in Manila and the management was carried out by farm manager(s) and a number of overseers. The tenure contract was geared more strictly to economic considerations, and it was enforced more strongly. . . . (Kikuchi et al. 1978, p. 7.)

The land reform may be assumed to have affected Central Luzon more than Laguna. Certainly the study by Takahashi (1969) in an area of Central Luzon around Baliwag (see figure I.2) did reveal considerable inequality of landownership in 1953 and 1964. For example, in an area of 28,751 hectares, he calculated that 26(25) owners out of a total of 11,184 landlords owned 3,614 (3,527) hectares in 1953 (1964). That is, less than one-quarter of one percent of owners owned about 12.6 percent of the land. These same owners may have had additional land outside the district; the largest owner had more than 700 hectares within it. Similarly, in a smaller scale study, Takahashi found that of 3,444 hectares of irrigated land, 17 percent was owned by 2 percent of owners.

A combination of the institutional changes which evolved from the Philippine land reform and the adoption of improved rice technology led to significant social change in both Laguna and Central Luzon. In both areas adoption of modern rice varieties and irrigation have been the most influential technical improvements. The short, stiff-strawed modern varieties increased yields and are not photo-period sensitive. Traditional varieties grew throughout the wet season and matured in November when day length shortened and the rains had ceased; consequently, harvest and threshing was completed on relatively dry paddy land. The MV matured during the wet season, and with irrigation their growing season requirements were short enough so that two crops were possible.

In both Laguna and Central Luzon, rice is harvested by sickle, however, the threshing technique differs greatly. Virtually all rice in Laguna is threshed by hand flailing. Historically, the harvest laborer in Laguna received one-sixth of the crop in return for harvesting and threshing. As MV increased yields, a sixth of the production meant that harvest laborers realized a higher wage rate. In addition, the land reform and population growth created a labor surplus situation in Laguna. Landlords were reluctant to lower the one-sixth share for harvesters since this proportion was deeply rooted in the patron-client relationship of Laguna. As a result, a new system has evolved whereby harvesters contribute weeding labor at no cost in return for the right to harvest at the traditional one-sixth share. Interestingly, this system is perceived to be advantageous to both landlord and tenant, as well as landless laborer. The landlord obtains weeding labor for "free" and does not pay a larger share to harvest laborers. Tenants can utilize family labor in rice production, but find the new arrangement releases them from the task of locating labor at the time of peak harvest demand. And landless laborers find that by participating in weeding they have assured access to harvest activities and the resultant one-sixth share of an increased yield. It would then appear that the social structure and patron-client relationship in Laguna have been strengthened by the dual forces of land reform and modernization of rice production.

In Central Luzon, rice production was carefully controlled by overseers on large estates. Since the early 1920's a very significant part of the rice produced on these estates was threshed with large mechanical threshing machines. There were two fundamental reasons for use of the threshing machine. First, laborers were not as numerous during the peak labor periods, such as transplanting and harvest, and second, the threshing machine was used as a control mechanism to insure that the landlord received his agreed upon share of production. Briefly, the pre-land reform harvest system of Central Luzon worked as follows. The harvest laborer would cut the rice, receiving a wage either on a daily basis or for cutting a given area of land. The bundled rice was stacked in the field awaiting threshing; there was little risk of waste or spoilage since indigenous rice varieties didn't mature until after the wet season terminated. The threshing machine, either owned or leased by the landlord, would arrive at a particular site and under the watchful eye of the overseer the threshing operation took place. The landlord and tenant shares were designated after payment of 4-6 percent to the operator of the threshing machine.

With the advent of the land reform, the parcels of land operated by farmers were considerably reduced making mechanical threshing less efficient. And with the introduction of MV, the wet season crop was harvested while fields were still flooded and muddy. This made it impractical to stack the cut rice or move the heavy threshing machines from one site to another. By 1978, virtually all of the large threshing machines had been abandoned, with threshing becoming a hand operation as in Laguna. In Central Luzon, agricultural technology, and specifically, irrigation during the dry season and MV, have led to double cropping and a more uniform demand for labor throughout the year. This, in addition to the land reform and the demise of mechanized threshing which symbolized hacienda control, has led to a significant change in the class structure of those producing rice.

Certainly the shift to hand threshing has provided a significant increase in labor required; landless laborers have been the beneficiaries. This is verified by Ranade (1977) through production function analysis, and Kikuchi et al. (1978). Kikuchi found that the average cost of harvesting and threshing was 765 pesos/ha, with 247 pesos/ha (32 percent) going to capital. Under the system of hand threshing the total cost was 812 pesos with no payment to capital. The absolute quantity of hired labor also increased substantially. It would appear that in this instance the much maligned Green Revolution, coupled with land reform, has led to a more egalitarian structure, with the lot of the landless laborer improved.

Chittoor District, India. In all of the study villages of Chittoor District, caste is a major factor in land ownership and socio-political status. In the District as a whole, Brahmins, Reddys, Kammas, and Balijas are the main landowning castes. In the four sample sets of farmers the Reddys and Kammas predominate--out of 99 sample farmers only one is a Brahmin and only two are from scheduled castes or tribes. Thus the scheduled castes, despite constituting approximately 20 percent of the population, are largely excluded from landholding, and serve primarily as laborers.

In contrast to Indonesia and the Philippines, it is comparatively unusual for land to be rented out, and most landowners farm their own land. No major land reform has taken place since the end of the 19th century. At present, land reform legislation is on the books; however, no action has been taken and fear of land partitioning is not a factor in determining how land will be used or in long range capital expenditures.

Relationships between landowners and landless laborers are considerably different than in either the Indonesian or Philippine study areas. Virtually all non-family labor on sampled farms was hired for wages; share-cropping and tenant farming are not practiced. On larger farms, some labor is hired on an annual basis with small cash payments made to the male head of a hired family. These relationships frequently last for many years and several generations of indentured labor are not uncommon. There are a variety of perquisites provided, the most common being clothing and food. Housing may be in the form of allowing the hired family to build on land owned by the landholder, or in some sampled homes quarters were provided for long term labor. This "indentured" relationship exists for 10-15 percent of the total labor hired by the sampled households.

The bulk of hired labor might be referred to as "casual" labor hired on a daily basis, or for some activities, contracted on a piecework basis. Sugar cane laborers may be paid by the day or for harvesting a given are of cane. Some longer term contract labor, for periods of 1-3 weeks, may be used for specific tasks such as planting sugar cane or weeding paddy. Labor is most scarce in Madanapalle; this is reflected in higher wage rates and more labor being carried out on a piecework basis. Daily wages in this cluster of villages average about 20 percent higher than ir other sites. Hired labor is used in harvesting rice, but daily wages are paid, rather than harvesters receiving a share of the crop. Wage rates may rise from 4.5 Rp/day on the average to 6.0 Rp/day during the harvest season.

The reader should keep in mind that all of the householders sampled were landowning. Although caste is important regarding social status and political influence, the size of land holdings is the most important determinant of wealth. Landless laborers were not interviewed; their economic and social status is considerably below the landowners in Chittoor.

The Distribution of Productive Assets and Land/Labor Ratios

The way in which land is distributed among rural families, and the availability of land per capita importantly affect agricultural practices and the potential for increased agricultural output. The average size of land holdings differs significantly between the study sites. It is ludicrous to presume that these three areas which constitute mere specks on a map of Asia are representative of the entire continent. The patterns of land ownership are such an important factor that it is desirable to provide statistics concerning average farm size and the distribution of holdings in various size categories for as wide a range of Asian locales as possible. To this end tables I.12, I.13, and I.14 are presented on the following pages. They supply data for specific locales in five important rice producing nations of Asia. These tables are presented in advance of an analysis of the Indonesian, Philippine, and Indian sites in order to provide an overview of the area and as a reference for similar measures which will be presented for the study villages.

Table I.12 shows average farm size and the proportion of farms in nine size categories. The largest holdings are in Thailand, where two sites show farm sizes over 7 hectares. The Indian sites exhibit considerable variability. Two have average holdings of .6 hectares, but four show average farm sizes in excess of two hectares. The sizes of the Indonesian sites cluster around .5 hectares. In the Philippines, the size of farm holdings varies from locale to locale with a range of 1.2 to 3.9 hectares. The table also contrasts patterns of land holdings by size category. For example, in Cidahu, Indonesia, 38 percent are under .3 hectares, while none of the Thai villages had farms of less than .3 hectares.

Table I.13 shows Gini coefficients, which provide a rough indication of the equality of land holdings. In theory the coefficients can range from zero to 1. A Gini coefficient of zero would indicate perfect equality of land holdings, i.e., every farmer with exactly the same size farm. As the Gini coefficient approaches 1, it provides an indication of the in-

TABLE I.12.--Cumulative Distribution of Operating Units (Rice-Growing Farms) by Size in 30 Villages in Asia, 1971/72

Location	Avg. farm size (ha)	Class-size (ha) < 0.3	0.31 - 0.49	0.50 - 0.90	1.0 - 1.9	2.0 - 2.9	3.0 - 3.9	4.0 - 4.9	5.0 - 9.9	> 10
		%								
Cidahu, Indonesia	0.5	38	54	82	97	100				
Nganjat, Indonesia	0.5	36	76	85	100					
Korpada, India	0.6	27	44	79	98	100				
Kahuman, Indonesia	0.6	25	49	81	100					
Kandarpur, India	0.6	23	54	79	100					
Sidomulyo, Indonesia	0.5	24	66	98	100					
Tab-ang, Philippines	1.2	23	27	52	79	95	100			
Pluneng, Indonesia	0.5	21	33	89	100					
Barain, India	1.2	7	14	39	72	90	100			
Marcos, Philippines	1.5	4	12	39	77	91	95	97	100	
Pedapulleru, India	4.7	4	7	16	39	59	65	73	87	100
Salor, Malaysia	0.9	4	23	66	99	100				
Meranti, Malaysia	1.0	4	17	58	94	99	100			
B. Nuwebe, Philippines	1.7	1	3	15	60	90	99	100		
Tarna, India	1.2	0	7	37	74	86	95	100		
Gajanur, India	2.4	0	6	23	52	73	88	94	100	
Canipa, Philippines	1.7	0	4	16	63	90	98	100		
Nong Sarai, Thailand	7.8	0	2	2	4	6	8	23	83	100
Ashoknagar, India	2.8	0	2	10	26	58	78	94	100	
Hosahally, India	4.8	0	2	7	14	40	47	61	93	100
Sinayawan, Philippines	2.2	0	1	15	57	79	88	93	100	
Maluao, Philippines	2.9	0	0	8	44	80	88	92	100	
Capayuran, Philippines	1.9	0	0	3	45	83	97	100		
Malimba, Philippines	3.1	0	0	2	11	44	88	92	100	
Bulucaon, Philippines	2.0	0	0	0	28	98	100			
San Nicolas, Philippines	2.5	0	0	0	20	54	92	96	100	
Mahipon, Philippines	3.8	0	0	0	4	18	61	83	100	
Rai Rot, Thailand	7.0	0	0	0	4	4	17	23	85	100
Sa Krachom, Thailand	7.8	0	0	0	2	7	18	25	75	100
Cabpangi, Philippines	3.9	0	0	0	0	40	46	92	100	

Source: IRRI (1978a), p. 90.

TABLE I.13.--Cumulative Distribution of Area by Farm Size for 30 Asian Rice Villages, 1971/72

Location	Gini coefficient	Class-Size (ha) < 0.3	0.31 - 0.49	0.5 - 0.9	1.0 - 1.9	2.0 - 2.9	3.0 - 3.9	4.0 - 4.9	5.0 - 9.9	> 10
		(%)								
India										
Pedapulleru	0.56	0	1	2	7	17	21	28	50	100
Tarna	0.42	0	2	13	42	57	76	100		
Barain	0.43	1	3	14	39	63	100			
Gajanur	0.38	0	1	7	25	46	67	79	100	
Hosahally	0.34	0	0	1	3	16	21	34	82	100
Ashoknagar	0.27	0	1	3	11	38	61	85	100	
Kandarpur	0.32	7	27	56	100					
Korpada	0.32	9	2	57	93	100				
Indonesia										
Nganjat	0.34	12	45	55	100					
Kahuman	0.30	8	24	65	100					
Pluneng	0.25	8	17	74	100					
Sidomulyo	0.25	10	46	95	100					
Cidahu	0.36	14	25	57	91	100				
West Malaysia										
Salor	0.24	1	10	46	97	100				
Meranti	0.27	1	6	46	85	97	100			
Thailand										
Rai Rot	0.18	0	0	0	1	2	7	11	76	100
Nong Sarai	0.24	0	0	0	1	2	2	11	66	100
Sa Krachom	0.25	0	0	0	1	2	7	11	56	100
Philippines										
San Nicolas	0.13	0	0	0	10	47	86	92	100	
Malimba	0.20	0	0	1	5	31	76	82	100	
Mahipon	0.17	0	0	0	2	10	48	73	100	
Canipa	0.27	0	1	6	42	78	94	100		
Marcos	0.38	1	2	15	50	73	83	88	100	
Tab-ang	0.43	8	6	18	51	85	100			
B. Nuwebe	0.28	0	0	4	38	79	95	100		
Sinayawan	0.38	0	0	5	28	52	65	75	100	
Bulucaon	0.25	0	0	0	16	95	100			
Maluao	0.46	0	0	2	17	44	53	57	100	
Capayuran	0.22	0	0	1	27	72	94	100		
Cabpangi	0.22	0	0	2	17	44	53	57	100	

Source: IRRI (1978a), p. 102.

TABLE I.14.--Distribution of Ownership Holdings Ranked by Gini Coefficient for Selected Farm Villages in Asia[a]

Location	Gini coef-ficient	Cumulative % of farm area at cumulative % of holdings 10	20	30	40	50	60	70	80	90	95	100
							India					
Andhra Pradesh												
Pedapulleru	.56	1	3	6	10	13	18	27	40	57	75	100
Orissa												
Kandarpur	.32	3	6	11	18	24	33	44	58	75	85	100
Korpada	.32	3	6	11	18	25	35	45	60	75	85	100
							Indonesia					
Central Java												
Nganjat	.34	2	5	10	17	25	33	42	54	65	78	100
West Java												
Cidahu	.36	2	5	9	14	20	29	39	54	72	83	100
							Malaysia					
Kelantan												
Salor	.24	3	8	15	23	30	40	50	65	80	89	100
Meranti	.27	3	8	14	21	30	38	50	64	80	89	100
							Thailand					
Suphan Buri												
Rai Rot	.18	4	10	16	25	33	44	55	68	82	90	100
Nong Sarai	.24	4	10	16	24	33	41	51	63	76	85	100
Sa Krachom	.25	3	7	14	21	30	40	50	63	79	88	100
							Philippines					
Nueva Ecija												
San Nicolas	.13	3	10	18	21	35	45	57	69	83	90	100
Malimba	.20	5	11	19	26	35	45	56	66	80	89	100
Mahipon	.17	5	12	19	22	35	45	56	68	83	89	100
Leyte												
Marcos	.38	2	5	10	15	22	31	41	53	71	82	100
Canipa	.27	4	9	14	20	29	38	49	63	79	87	100
Tab-ang	.43	2	5	8	13	19	28	40	55	75	85	100

TABLE I.14.--cont.

Location	Gini coef-ficient	Cumulative % of farm area at cumulative % of holdings 10	20	30	40	50	60	70	80	90	95	100
Davao												
Beynte Nuwebe	.28	3	8	14	21	30	39	50	60	80	89	100
Sinayawan	.38	3	12	12	12	23	30	40	52	69	80	100
Cotabato												
Bulucaon	.25	4	9	18	28	37	42	59	70	84	90	100
							India					
Uttar Pradesh												
Dhanpur-Vijaypur	.28	3	7	13	20	27	35	44	57	75	85	100
Mysore												
Gajanur	.38	2	6	11	17	24	33	43	55	71	81	100
Hosahally	.34	2	6	11	13	26	44	55	69	83	90	100
Ashoknagar	.27	3	8	15	22	30	40	51	64	79	86	100
							Indonesia					
East Java												
Sidomulyo	.25	4	10	17	24	30	40	51	62	80	89	100
Central Java												
Pluneng	.25	4	9	15	23	32	42	51	62	77	86	100
Kahuman	.30	3	6	10	17	25	35	47	62	79	88	100
							Philippines					
Cotabato												
Capayuran	.22	4	10	16	24	33	43	54	67	81	90	100
Cabpangi	.22	5	11	18	24	34	44	55	68	82	90	100
Maluao	.46	3	6	11	15	20	28	35	44	55	65	100

Source: IRRI (1978a), p. 106.

[a]Values are cumulative % farm areas at specified cumulative % of holdings interpolated from individual Lorenz curve of each village. Farm size grouping different for each village.

creasing disparity of land holdings. Thus, a Gini coefficient of .1 would indicate fairly equitable land distribution, while a coefficient of .8 would indicate that a relatively small number of farmers held most of the land. According to table I.13 then, the most inequitable land holding exists in Pedapulleru, India, with a coefficient of .56. In general, the distribution appears less skewed in Indonesia with coefficients averaging .30. It should be borne in mind that Gini coefficients are rather crude measures and are used here only as a rough analytical tool. The relative magnitude of the coefficient is far more important than the absolute value, since they can be easily distorted by imprecise definitions of land ownership ("tenants" versus "sharecroppers"), as well as imprecise measurement of land "controlled" and land "owned."

Table I.14 provides another way to look at the distribution of land holdings. Some interpretation may be in order. For example, the table indicates that in Pedapulleru, 1 percent of land holdings are held by the smallest 10 percent of farmers, while the 10 percent of the farmers with the largest holdings own 43 percent of the land (100 minus 57).

Village A, Central Java, Indonesia. The population density of the village at the time of the survey was somewhat below the average for Central Javanese villages. Measures of average size of holdings by different size categories for Village A are presented in tables I.15 and I.16. At a density equivalent of 768 persons per square kilometer, the population pressure on the land is less than half of that reported by Utami and Ihalauw (1978) for the IRRI survey villages. This difference in population-to-land ratios is not fully translated into differences in average

TABLE I.15.--The Distribution of Land Ownership, Operation, and Control in Village A, Central Java, Indonesia

Size groups (hectares)	Ownership		Operation		Control	
	Percent of households	Percent of land	Percent of households	Percent of land	Percent of households	Percent of land
None	48.8	0	34.9	0	33.7	0
0-0.100	2.4	0.4	7.0	1.5	12.8	2.0
0.101-0.200	0	0	11.6	4.1	7.0	2.9
Subtotal	51.2	0.4	53.5	5.6	53.5	4.9
0.201-0.300	5.8	3.8	11.6	7.3	9.3	5.5
0.301-0.400	9.4	8.0	8.1	6.3	11.6	10.1
0.401-0.500	4.6	4.8	8.2	8.4	5.8	6.2
Subtotal	19.8	16.6	27.9	22.0	26.7	21.8
0.501-0.600	12.8	16.5	4.7	6.2	7.0	9.4
0.601-0.700	5.8	9.4	2.3	3.6	3.5	5.7
0.701-1.00	2.3	5.0	4.6	8.8	0	0
Subtotal	20.9	30.9	11.6	18.6	10.5	15.1
1.01+	8.1	51.1	7.0	53.8	9.3	58.2
Total	100	100	100	100	100	100

Source: Hart (1978), p. 91.

TABLE I.16.--Cumulative Frequency Distributions of Operated Holdings in Terms of Number and Area by Size Class, Village A, Central Java, Indonesia

Holding size (ha)	Cumulative distribution of number of holdings (%)	Cumulative distribution of area (%)
0.1 - 0.3	39.9	11.6
0.301 - 0.5	68.0	26.5
0.501 - 1.0	88.0	45.4
1.001 plus	100.0	100.0

Source: Adapted from Hart (1978), p. 91.

area of rice land per operational holding. In Village A, the average size was 0.79 hectares as compared to 0.5, 0.6, and 0.5 hectares, respectively, in the three IRRI survey villages in Indonesia. This may be due to the fact that the proportion of landless households is somewhat less in Village A, although, as can be seen from table I.15, the proportion of landless households is still high, with 49 percent owning no land and 35 percent not operating any land. But even these figures understate the effective extent of landlessness in the village. Given that some holdings in the 0 to 0.1 hectare range are only garden plots around the family's hut, and that 0.2 hectares has been estimated (reported by Hart, 1978, p. 94) as the minimum holding required to provide a family's staple needs, Hart elects to classify all those operating less than 0.2 hectares as landless or near landless. Over half the households in the village are therefore classified in this category.

However, for the purpose of comparing the size distribution of operational holdings in Hart's village with the data available for the IRRI survey villages which do not include the landless, it seems appropriate to assume that all households with less than 0.1 hectares are landless. With this adjustment the cumulative frequency distribution of numbers of holdings and areas of holdings by size are as presented in table I.16. This is not precisely in the same form as the data presented in table I.12, but it is adequate to facilitate comparison with the other Central Javanese villages of Nganjat, Kahuman, and Pluneng. As can be seen, the land distribution is somewhat less equal in Village A than in any of these other villages. Not only does it have a greater proportion of operational holdings in the smallest category (even after excluding "holdings" of less than 0.1 hectares), but there would seem to be a higher proportion of large farms.

This last observation is not immediately deducible from table I.12, but is based on the additional facts that in Village A there are at least two holdings larger than 4 hectares (the headman and secretary have land grants of 9.4 and 4.6 hectares, respectively) and that over 54 percent of land is in operated holdings larger than one hectare (table I.16); whereas the largest 10 percent of holdings owned in Nganjat, Kuhuman, and Pluneng contain only 35, 21, and 23 percent of the land, respectively (table I.14). Moreover, the Gini coefficient implied by the data in table I.16 for operated holdings in the village is a rather high 0.53, indicating a substantial degree of inequality. To further compound this picture of an unequal pattern of control over productive assets, the only other major type of asset in the village, the 20 hectares of fishponds, also appear to be owned predominantly by the larger rice farmers, since, as Hart (1978, p. 94) reports, the average fishpond owner controls 1.24 hectares of land.

The distribution of secondary productive assets--primarily home gardens and livestock--is somewhat more equitable than that of rice land, but is clearly closely related to the control of rice land (table I.17). A household that does not own the land on which its house stands is known as a penumpang. While a penumpang does not generally pay rent, the owner of the land is entitled to the produce of any trees on the land surrounding the house. This land is usually too small for cultivation of anything

TABLE I.17.--Inter-class Differences in Ownership of Secondary Productive Assets in Village A, Central Java, Indonesia

	Class I	Class II	Class III	F
Home garden and house plot ownership:				
No. of owners/class	18	28	22	
% of owners/class	90.0	96.6	59.5	
Avg. area (owners only) (m^2)	1060	488	384	
Avg. area (all households) (m^2)	954	471	228	8.31
Home garden availability for cultivation:[a]				
No. of operators/class	18	28	22	
% of operators/class	90.0	96.6	59.5	
Avg. area (operators only) (m^2)	881	387	313	4.19
Avg. area (all households) (m^2)	793	373	186	6.33
Avg. value of other productive assets (Rp'000):[b]				
Livestock	60.1	8.8	2.1	4.99
Agricultural equipment	14.8	7.0	3.0	5.02
Fishing equipment	1.4	1.6	1.1	0.18

Source: Hart (1978), p. 108.

[a]The total area of the compound minus the area of the house.

[b]Rp 420 = U.S. $1.

other than a few herbs. In general, pekarangans (home gardens) in the study village are smaller and less intensively cultivated than has been reported elsewhere in Java, although fruit trees (primarily coconut and banana) grow in abundance. One of the apparent reasons for the low intensity of cultivation is that the area surrounding the house is used for drying rice at harvest time.

The sampled Village A households were divided into three classes. Class I households are those judged to have sufficient assets to be self-sufficient, with a net income equivalent to 300 kg milled rice per consumer; Class II households are those with sufficient assets to cover staple food needs of 150 kg milled rice per consumer; and Class III households do not control sufficient productive assets to meet even staple food needs. Three of the largest Class I households own water buffalo which are used for the plowing and harrowing of the households' land, and are also hired out. The buffalo population of the village has apparently declined over time, and there has been a marked substitution of human for animal labor in land preparation. Eleven households own ducks, and for three of these (two in Class II and one in Class III) the sale of duck eggs constitutes a major source of income. Virtually all households own a few chickens which are an important form of saving for the poor, as chickens are frequently sold in the slack season before the harvest.

While the quality of housing and the range of household possessions of even the wealthiest households are very modest by Western standards, inter-class differences in "household capital" are enormous (table I.18). These disparities are so marked that one can often guess quite accurately

TABLE I.18.--Inter-class Differences in Household Possessions in Village A, Central Java, Indonesia

	Class I	Class II	Class III	F
Avg. value of household possessions (Rp'000):				
Kitchen equipment	28.9	8.1	4.4	20.15
Furniture	65.3	18.3	5.3	26.96
Durables[a]	30.9	2.3	1.3	25.08
Vehicles	34.2	2.2	0	2.74
Avg. value of house (Rp'000)	504.0	161.2	29.1	33.57

Source: Hart (1978), p. 109.

[a]Sewing machines, radios, tape recorders, and clocks.

how much rice land a household controls from the size and quality of its house and furnishings. Apart from the mosque and school, there are no brick buildings in the village. Better quality houses are constructed of wood, and have tiled or cement floors and shingled roofs. The typical landless household lives in a small, windowless hut made of woven bamboo with mud floors, containing little other than a wooden bed frame. Several of these inter-class differences in the nature and quality of household possessions have quite important implications for the amount of time allocated to housework.

Laguna and Central Luzon, Philippines. In the case of these survey areas, samples were drawn from farm operators within villages and no attempt was made to study the whole population or the entire village area. The same holds true of the Chittoor District study in Andhra Pradesh. Consequently population-to-land ratios for both the Indian and Philippine study areas, and the cumulative holding size distributions for the population are unknown. Fortunately there are data from a survey conducted in Central Luzon which do allow generalizations on the distribution of land holdings.

Kikuchi et al. (1977) studied a Laguna barrio in depth, which, because of the homogeneity of the area, might be expected to exhibit characteristics similar to Cabuyao and Calamba. Table I.19 displays data for this Laguna barrio, showing the distribution of area and holding numbers by size class of operated holdings. It will be seen from this table that the average holding size of 2.0 hectares in 1976 is slightly above the 1.8 and 1.7 hectares for Cabuyao and Calamba, respectively. Inspection sug-

TABLE I.19.--Farm-Size Distribution[a] in a Laguna Village, Philippines

	1956		1966		1974		1975	
	Number of farmers	Rice area	Number of farmers	Rice area	Number of farmers	Rice area	Number of farmers	Rice area
	no. (%)	ha (%)	no. (%)	ha (%)	no. (%)	ha (%)	no. (%)	ha (%)
Below 1 ha	5 (16)	3 (3)	6 (13)	3 (3)	8 (15)	4 (4)	13 (24)	6 (6)
1 ha - 1.9 ha	9 (29)	12 (17)	14 (30)	18 (17)	22 (41)	29 (26)	20 (37)	28 (26)
2 ha - 2.9 ha	4 (13)	9 (13)	10 (22)	21 (20)	11 (20)	24 (22)	8 (15)	18 (17)
3 ha - 4.9 ha	12 (39)	42 (59)	13 (28)	46 (44)	11 (20)	40 (36)	11 (20)	41 (38)
5 ha and above	1 (3)	6 (8)	3 (7)	17 (16)	2 (4)	14 (13)	2 (4)	14 (13)
Total	31 (100)	71 (100)	46 (100)	104 (100)	54 (100)	111 (100)	54 (100)	108 (100)
Average rice area per farm (ha)	2.3		2.3		2.1		2.0	

Source: Kikuchi et al. (1977), table 9.

[a]Farm size in terms of the operational holding of paddy field.

gests that the degree of equality in land operation in the barrio is not particularly high, and in fact the implied Gini coefficient is 0.38. As can be seen from table I.13, this is a relatively high figure for a Philippine village and is appreciably higher than for the three IRRI sample villages in Central Luzon. These villages, San Nicolas, Malimba, and Mahipon, which are all in Central Luzon, have comparable Gini coefficient values of 0.13, 0.17, and 0.20, respectively.

While discussing Kikuchi's data, it is perhaps of interest to note the observed distributional changes through time. Between 1966 and 1976 it appears that the number of both landlords and farm operators increased, but the increase in the former of 25, greatly exceeded that of 8 in the latter (see tables I.19 and I.20). This pattern is consistent with the land reform which, as already noted, had the objective of reducing large landholdings and changing tenants into owners. Nevertheless, it is rather surprising that landowners outnumbered operators by 66 to 54 in 1976. This is especially so in view of the number of landless worker-families in the barrio that may be assumed to be striving for tenant status. According to the interesting data collected by Kikuchi et al. (1977), presented in tables I.21 and I.22, there has been fairly rapid growth in the number of landless households, from 20 in 1966, to 54 in 1976. Of further interest is the fact that approximately half of these households are immigrants (as are also half of the farming households) who have been attracted by perceived opportunities for work. Immigration on this scale suggests a high degree of fluidity in labor markets and social systems, and it also suggests that there is still growth in labor demand.

TABLE I.20.--Distribution of Landlords Owning Rice Land in a Laguna Barrio, Philippines[a]

	1976		1966
	Landlords (no.)	Area owned (ha)	Landlords (no.)
Distribution by residence:			
This barrio	4	2.4	3
The same municipality (except this barrio)	34	56.6	32
Laguna province (except this municipality)	7	11.7	4
Batangas province	14	17.6	2
Rizal province	5	15.7	0
Manila	1	2.2	0
Baguio	1	2.0	0
Total	66	108.2	41
Distribution by ownership size:			
Less than 1 ha	20	10.2	na
1 to 2.9 ha	34	46.2	na
3 to 6.9 ha	11	38.2	na
More than 7 ha	1	13.6	na
Total	66	108.2	na

Source: Kikuchi et al. (1977), table 8.

[a]Only for the areas that the farmers in the barrio are cultivating.

TABLE I.21.-- Changes in the Number of Households in a Laguna Barrio, Philippines[a]

	Farmers	Landless Workers	Total
1966	46	20	66
	(70)	(30)	(100)
1974	55	40	95
	(58)	(52)	(100)
1976	55	54	109
	(50)	(50)	(100)
1974/1966	1.20	2.00	1.44
1976/1966	1.20	2.70	1.65

Source: Kikuchi et al. (1977), table 4.

[a]Percentages in parentheses.

TABLE I.22.--Causes of the Formation of Households in a Laguna Barrio, Philippines[a]

Date of household formation	Migration			Independence			
	Farmer house-hold (1)	Landless worker household (2)	Total (3) = (1)+(2)	Farmer house-hold (4)	Landless worker household (5)	Total (6) = (4)+(5)	Total (7) = (3)+(6)
	---Number of households[a]---						
Before 1939	2 (15)	- (-)	2 (15)	9 (70)	2 (15)	11 (85)	13 (100)
1940-49	4 (31)	1 (7)	5 (38)	5 (38)	3 (23)	8 (61)	13 (100)
1950-59	2 (11)	1 (6)	3 (17)	9 (50)	6 (33)	15 (83)	18 (100)
1960-69	5 (17)	2 (7)	7 (24)	10 (35)	12 (41)	22 (76)	29 (100)
1970-76	6 (16)	11 (31)	17 (47)	3 (8)	16 (45)	19 (53)	36 (100)
Total	19 (18)	15 (14)	34 (31)	36 (33)	39 (36)	75 (69)	109 (100)

Source: Kikuchi et al. (1977), table 5.

[a]Figures inside of the parentheses are percentages.

Perhaps it should be observed that there is every reason to suppose that the sampled farms are representative of conditions in Central Luzon. The average sizes of holdings in the samples are, as expected, appreciably higher than for the village in Central Java, reflecting the lower man-land ratio in the Philippines. As will be seen in later sections of the report, agricultural changes and responses observed on the sample farms are also consistent with what might have been expected. Ranade (1977) did not collect information concerning non-land assets, however, it is useful to have some background knowledge as to the quality of housing, availability of potable water and other indicators of rural welfare. Guino and Barker (1976) have data describing housing characteristics for two farming communities of Central Luzon. According to the data virtually all farmers owned their own homes, although dwellings varied in quality. Since the advent of MV and other technical improvements in agriculture, nearly half of the surveyed farmers had made substantial improvements in housing or purchased consumer durables. Proximity to arteries of transportation importantly influenced the spread of technology and hence, observable improvements in level of living. For example, nearly 64 percent of houses close to market centers had metal roofs; 78 percent had concrete walls, and 38 percent had indoor toilets. In households more distant from transportation or villages the percentages were respectively, 52, 61, and 18. Inspection of these data indicate an improvement in housing and sanitation for all classes of households.

Chittoor District, India. The average size of the sampled holdings in Chittoor District, at 4.55 hectares (table I.23), is appreciably larger

TABLE I.23.--Selected Characteristics of Farms in Eight Size Categories in Chittoor District, India, 1976

Operational size (acres)	Number of farms			Operated area (acres)			Net area sown as % of operated area			Gross cropped area as % of operated area		
	1	2	3	1	2	3	1	2	3	1	2	3
0 - 2	3	-	3	1.00	-	1.00	100	-	100	189	-	189
2 - 4	15	-	15	3.29	-	3.29	94	-	94	142	-	142
4 - 8	30	4	34	5.96	6.73	6.05	97	93	97	127	99	123
8 - 12	11	6	17	9.54	9.72	9.61	97	93	96	133	123	129
12 - 20	10	6	16	15.24	15.95	15.50	94	100	96	123	158	136
20 - 28	2	7	9	22.19	24.40	23.91	95	95	95	97	115	111
28 - 36	1	2	3	29.41	31.05	30.50	61	100	87	64	128	108
36 +	-	3	3	-	47.21	47.21	-	80	80	-	91	91
All	71	28	99	7.83	19.83	11.23	94	92	93	123	118	120

Operational size (acres)	Cultivable waste + fallows as % of operated area			Own irrigated land as % of operated area			Own irrigated land as % of own land			Operated area irrigated as % of total operated area		
	1	2	3	1	2	3	1	2	3	1	2	3
0 - 2	0	-	-	100	-	100	100	-	100	100	-	100
2 - 4	6	-	6	84	-	84	87	-	87	88	-	88
4 - 8	3	7	3	77	70	76	71	67	71	73	66	72
8 - 12	3	7	4	58	88	68	61	75	67	59	71	63
12 - 20	6	0	4	74	69	72	75	76	75	75	79	76
20 - 28	5	5	5	49	82	75	49	82	75	49	82	75
28 - 36	39	0	13	52	71	65	52	71	65	52	72	65
36 +	-	20	20	-	46	46	-	46	46	-	46	46
All	6	8	7	70	70	70	69	69	69	69	69	69

Source: Doraswamy (1979).

Note: Figures under column No. 1 refer to non-tractor owners.
Figures under column No. 2 refer to tractor owners.
Figures under column No. 3 refer to all farms.

than for Central Java and the Philippines. It does, however, seem to be a fairly characteristic size and is close to the 4.7 hectare average holding for the IRRI survey village of Pedapulleru in Andhra Pradesh (see table I.12). There is, however, a wide distribution of sizes around this mean, and three out of the 99 sampled farms exceeded 14.6 hectares, with a mean area of 19.1 hectares. Since 70 percent of the area on the sample farms is irrigated, this relatively large size cannot be attributed to inherently low productivity. Rather, it reflects the much lower population-to-land pressure which exists in India in comparison to Indonesia and the Philippines, and which is illustrated by the last column of table I.7.

The Gini coefficient implied by the data in table I.23 for the relationship between holdings and area farmed is 0.41. This is higher than for the other study areas, indicating a greater degree of inequality in land operation, and this too is consistent with expectations formed on the basis of the IRRI survey data reported in table I.13. However, it is evident that this crude measure of inequality of land operation in Chittoor overstates the case; for as can also be seen from the last column of table I.23, the proportion of the area irrigated is substantially less for large than for small farms, indicating that the inherent productivity per hectare of the small farms is higher than for the large farms. This, while also to be expected, does suggest that the degree of inequality among operators of land is not as large as it superficially appears to be.

Before considering the data on ownership of productive assets other than land in tables I.23-I.25, it is important to note that the cluster of

TABLE I.24.--Average Value of Agricultural Assets per Farm, by Mechanization Class of Farm[a], Chittoor District, India, 1976 ('000 Rupees)[d]

	Class-Size of Farm (acres)								
	0 to 2	2 to 4	4 to 8	8 to 12	12 to 20	20 to 28	28 to 36	36 +	All Farms
Traditional Implements									
1	0.2	0.5	0.8	1.6	1.2	1.2	0.9	-	0.9
2	-	-	0.2	0.5	0.7	1.0	1.2	0.7	0.7
3	0.2	0.5	0.7	1.2	1.0	1.0	1.1	0.7	0.8
Irrigation Equipment									
1	1.2	2.7	3.9	3.6	6.6	5.5	9.9	-	4.0
2	-	-	3.3	5.5	7.6	5.7	9.0	5.5	6.0
3	1.2	2.7	3.8	4.3	7.0	5.7	9.3	5.5	4.6
Tractors									
1	-	-	-	-	-	-	-	-	-
2	-	-	30.0	33.3	30.5	32.1	42.5	31.7	32.4
3	-	-	3.5	11.8	11.4	25.0	28.3	31.7	9.2
Sugarcane Crushers									
1	-	0.1	0.5	0.6	1.7	1.5	2.0	-	0.6
2	-	-	1.6	-	0.6	0.5	-	16.7	0.7
3	-	0.1	0.6	0.4	1.3	0.8	0.7	16.7	0.6
Livestock									
1	1.3	2.1	2.2	3.0	4.0	6.7	4.1	-	2.7
2	-	-	2.5	2.4	4.1	3.9	7.4	4.4	3.7
3	1.3	2.1	2.3	2.8	4.0	4.5	6.3	4.4	3.0
Dwelling House									
1	7.9	19.2	17.6	24.5	31.4	57.7	6.0	-	21.5
2	-	-	9.0	28.8	28.7	32.9	40.0	26.7	27.5
3	7.9	19.2	16.6	26.0	30.4	38.4	28.7	26.7	23.2
Land									
1	11.7	60.9	112.4	144.5	230.5	292.6	323.0	-	127.6
2	-	-	145.4	192.5	235.1	368.9	523.8	436.2	288.8
3	11.7	60.9	116.3	161.4	232.2	351.9	456.9	436.2	173.2
Other[b]									
1	1.2	1.9	2.6	2.7	3.4	2.9	1.0	-	2.5
2	-	-	1.8	7.1	4.5	5.5	21.5	4.2	6.1
3	1.2	1.9	2.5	4.3	3.8	4.9	14.7	4.2	3.6
Total[c]									
1	23.4	87.4	140.0	180.6	278.9	368.0	346.9	-	159.9
2	-	-	193.7	270.2	311.6	450.5	645.4	510.9	365.8
3	23.4	87.4	146.3	212.2	291.2	432.2	545.9	510.9	218.1

Source: Doraswamy (1979).

[a]1 = non-tractor-owning farms; 2 = tractor-owning farms; 3 = all farms.
[b]Other assets consist mainly of farm buildings; e.g., tractor, cattle and pump sheds.
[c]Because of rounding errors the row totals are not always exactly 100 percent.
[d]The official exchange rate in 1976 was rupees 8.96 = US $1.

TABLE I.25.--Average Proportional Value of Agricultural Assets per Farm, by Mechanization Class of Farm[a], Chittoor District, India, 1976 (%)

	Class-Size of Farm (acres)								
	0 to 2	2 to 4	4 to 8	8 to 12	12 to 20	20 to 28	28 to 36	36 +	All Farms
Traditional Implements									
1	1.0	0.6	0.5	0.9	0.4	0.3	0.3	-	0.6
2	-	-	0.1	0.2	0.2	0.2	0.2	0.1	0.2
3	1.0	0.6	0.5	0.6	0.3	0.2	0.2	0.1	0.4
Irrigation Equipment									
1	5.0	3.1	2.8	2.0	2.4	1.5	2.8	-	2.5
2	-	-	1.7	2.0	2.4	1.3	1.4	1.1	1.6
3	5.0	3.1	2.6	2.0	2.4	1.3	1.7	1.1	1.2
Tractors									
1	-	-	-	-	-	-	-	-	-
2	-	-	15.5	12.3	9.8	7.1	6.6	6.2	8.9
3	-	-	2.4	5.5	3.9	5.7	5.2	6.2	4.2
Sugarcane Crushers									
1	-	0.1	0.3	0.3	0.6	0.4	0.6	-	0.4
2	-	-	0.8	-	0.2	0.1	-	0.3	0.2
3	-	0.1	0.4	0.2	0.4	0.2	0.1	0.3	0.3
Livestock									
1	5.4	2.4	1.6	1.7	1.4	1.8	1.2	-	1.7
2	-	-	1.3	0.9	1.3	0.9	1.1	0.9	1.0
3	5.4	2.4	1.5	1.3	1.4	1.0	1.1	0.9	1.4
Dwelling House									
1	33.8	21.9	12.6	13.6	11.3	15.7	1.7	-	13.4
2	-	-	4.6	10.7	9.2	7.3	6.2	5.2	7.5
3	33.8	21.9	11.2	12.3	10.4	8.9	5.3	5.2	10.6
Land									
1	49.8	69.7	80.2	80.1	82.6	79.5	93.1	-	79.8
2	-	-	75.1	71.2	75.4	81.9	81.2	85.4	78.9
3	49.8	69.7	79.5	76.1	79.7	81.4	83.7	85.4	79.4
Other[b]									
1	5.0	2.2	1.9	1.5	1.2	0.8	0.3	-	1.6
2	-	-	0.9	2.6	1.4	1.2	3.3	0.8	1.7
3	5.0	2.2	1.7	2.0	1.3	1.1	2.7	0.8	1.6
Total[c]									
1	100	100	100	100	100	100	100	100	100
2	100	100	100	100	100	100	100	100	100
3	100	100	100	100	100	100	100	100	100

Source: Doraswamy, (1979).

[a]1 = non-tractor-owning farms; 2 = tractor-owning farms; 3 = all farms.

[b]Other assets consist mainly of farm buildings; e.g., tractor, cattle and pump sheds.

[c]Because of rounding errors the row totals are not always exactly 100 percent.

villages within which the sampled farms are located were selected because of their high level of tractor ownership. This characteristic is amply reflected in the sample, and as can be seen from the first three columns of table I.23, no less than 28 out of the 99 farms owned four-wheel tractors, mostly of 35 horsepower, the 1978 replacement cost of which would be 60,000 rupees. None of these tractor owners are found in the smallest two acreage categories of farms, which largely reflects the fact that bank loans for the purchase of tractors require as collateral that farmers own a certain minimum acreage. In the case of Central Land Mortgage Bank, farmers obtaining loans are required to have at least 6 hectares of wet land or 12 hectares of dry land--most banks have requirements of a similar type. Thus it is hardly surprising that the proportion of farms owning tractors is shown to increase with the size of farms (table I.23)

In addition to tractors, farms in the Chittoor sample also own other important classes of inputs. In particular, irrigation equipment (pump sets) and livestock on average are owned to the extent of approximately one-quarter and one-third of the value of tractors, and both of these classes of assets constitute a higher proportion of total asset value on small farms than on large farms. As a relatively minor asset, sugar cane crushers are also found on all classes except the smallest.

Considering all productive assets other than land and dwellings, the average Chittoor sample farm of 4.55 hectares owned 21,734 rupees worth of assets, or 1,932 rupees per hectare. At the official 1976 exchange rate of 8.96 rupees per US dollar, this represents $216 worth of assets per acre. This is a far higher level of reproducible capital use than was found at the other study sites and indicates the prosperous nature of Chittoor farming. This conclusion is reinforced further when it is noted that some Chittoor farmers also owned substantial non-agricultural assets. For example, one sample farmer owned a cinema, one a workshop for constructing truck bodies, another had a vehicle replacement parts outlet, and two jointly operated a cotton waste business.

There are significant differences in the level of income among these households, but none can be considered as living in poverty. Eighty-five percent of homes sampled had electricity and virtually all had a dug or drilled well. Housing differentials were observed, with more affluent farmers having concrete homes, but even the smallest landholders had brick homes with well-made thatched roofs.

Sampling Procedures and Data Collection

All three of the Cornell/AID studies reported here were undertaken with the collaboration of an established institution or institutions in the country visited. In the case of Hart's study in Central Java, the collaborating institutions were the Indonesian Agro-Economic Survey (AES) and two local universities; for Ranade's study in the Philippines, it was the International Rice Research Institute (IRRI); and for Doraswamy's study in Chittoor District the associated organization was Sri Venkatasware University at Tirupati. The study sites for the Cornell/AID studies were selected from locations previously chosen by these institutions as part of earlier, broader, and ongoing research.

Village A, Central Java, Indonesia

The principal investigator for all field research conducted in Village A was Gillian Hart. The research reported in this study constituted a subsection of the Project on the Ecology of Coastal Villages, a joint project of AES, Universitas Diponegoro in Semarang, and Institut Pertanian Bogor. Field work was carried out jointly with Ir Suhardjo, lecturer at the Institut. In addition to his extensive research training and experience, Suhardjo was raised in a Javanese village and his sensitivity to different orders of meaning contributed greatly to the quality of the data.

When Hart arrived in Indonesia at the beginning of April 1975, the three villages in the Ecology Project had already been decided upon. All three were villages in which AES had been working for some time, and the research team was well-known to the village government officials. The villages were selected to reflect the range of economic activities common in villages along the north coast of Java--namely rice cultivation, brackish water fishponds (tambaks), and ocean fishing. The study village was chosen because of the predominance of rice cultivation; the characteristics of the other two villages (in which ocean fishing is important) have been described in "Second Report of the Project on the Ecology of Coastal Villages" (1975b).

Originally it had been planned to focus on the conditions of landless workers in two rice-cultivating village situations--a rainfed village, in which traditional rice varieties were predominant, and an irrigated one in which there was widespread adoption of high yielding varieties. On visiting the study site in April 1975, Hart found that most farmers had reverted to local varieties after suffering severe crop losses from pest infestation of high yield varieties. The possibility of including in the project an additional rice cultivating village which had not been affected by pests was investigated. However, pest infestation had been so widespread in that area of the north coast that it was not possible to locate such a village (this has been discussed in Hart and Hadikoesworo [1975]). In addition, it soon became evident that including an additional village would pose severe logistical problems, given the constant checking and supervision required in collecting detailed and comprehensive household data. Further, in addition to the data needs of the project as a whole, it also became clear that a sample of all households in the village was essential in order to understand the processes underlying poverty and low productivity, and that the original plan to interview landless households more intensively was too restrictive.

A census of landholdings of all households in the village conducted by AES in 1974 constituted the sampling frame. Initially it was decided that the largest feasible sample size was in the vicinity of 80 households. Eighty-seven households were initially selected, one of which subsequently dropped out. In the dry season, an additional six households were added to the sample.

The precise details of sampling procedures and the type of difficulties which were encountered have been described at length in "Methodology Report of the Project on the Ecology of Coastal Villages" (1975a). The basic aim was to select a sample as representative as possible of landholding patterns in the population. However, the data needs of the project as a whole were such that it was necessary to select a sufficiently large sample of fishpond owning households to allow for analysis of the operation of brackish water fishponds; this group, therefore, is somewhat overrepresented. Table I.26 summarizes landownership patterns in the population and the wet season sample of 86 households.

Landowning households were stratified on the basis of rice land owned, and within each stratum a proportional sample was selected systematically. The census data on landownership of each household were listed in descending order according to residential block or dukuh. Landowning households living in a particular residential block are likely to own rice land in an adjacent area of the village. From the basic listings, separate lists were

TABLE I.26.--The Distribution of Rice Land Ownership in the Population and Sample of Village A, Central Java, Indonesia

	Rice land (hectares)					Fishponds only	No rice land or fishponds
	1.0	.60-.99	.50-.59	.30-.49	.29		
Population							
No. of households	32	83	43	57	22	14	247
Household as % of population	6.4	16.7	8.6	11.4	4.4	2.8	49.7
Rice land owned as % of total	45.5	29.8	11.2	11.0	2.5		
Avg. area of rice land owned (ha)	2.77	0.69	0.51	0.38	0.22		
Sample							
No. of households	7	7	11	12	7	2	40
Household as % of population	8.1	8.1	12.9	14.0	8.1	2.3	46.5
Rice land owned as % of total	51.1	14.4	17.5	12.8	4.2		
Avg. area of rice land owned (ha)	2.56	0.72	0.56	0.37	0.21		

Source: Hart (1978), p. 291.

drawn up in which landowning households within each landholding size group were listed according to residential block; the systematic sampling procedure was intended to ensure that all four blocks would be represented proportionately. Landless households were randomly selected after excluding households containing only one member. In all, eleven replacements had to be made. Two of the originally selected households had left the village, and in a third the household head had died and the land was being operated by a relative. Three landowning households (all in the small to medium range) had either rented out or sold their land, and were no longer operating any land at all. The other five households which were replaced were all fishpond owning households; several of these denied fishpond ownership (closer investigation revealed that these households did own fishponds, but title deeds had not yet been issued), while others owned fishponds in another village and male members of the household were very rarely at home.

In the course of applying the Basic Data questionnaire it was found that landholding size reported in the interview frequently diverged from that listed in the census. As will be discussed below, data on landholdings proved the most difficult and complex to collect, and throughout the 18 months spent in the village this information was constantly revised. In part, the discrepancies between the census and interview data on landholdings are attributable to changes which had taken place in the intervening year, a period characterized by relatively depressed conditions. In many instances, however, they are due to the problems inherent in collecting this type of data. The general tendency seemed to be for very large landowning households to under-report the extent of their landholdings, while several of the smaller landowning households (particularly those who had lost control over a portion of their land in the recent past) tended to exaggerate slightly. It is worth mentioning that one field data problem common to all study sites was that of measuring land area and yield. If farm level data are to be meaningful these parameters must be measured carefully. The importance of accurately determining land area through modified surveying techniques, and estimating yields through precise weighting and measurement of sample cuttings cannot be overemphasized.

Laguna and Central Luzon, Philippines

The principal investigator in the Philippines was Dr. Chandrashekar Ranade. He conducted field work at two of the Philippine sites in 1974. Previous research had been conducted in Laguna and Central Luzon in 1966 and 1970. Ranade selected identical sites so that time series analysis would be possible. The assistance of two Philippine researchers was invaluable. Violetta Cordova worked with the Laguna survey. Her aid in the interpretation of field data, and placing the 1974 survey in historical perspective was extremely useful. Ricardo Guino provided similar help in regard to the Central Luzon survey.

Laguna. The survey was carried out on a partially revolving sample of farms in Laguna Province for both wet and dry seasons from 1965-66 to 1970-71. A random sample of 60 farms from each of three municipalities--Binan, Cabuyao, and Calamba--was drawn. The municipalities were selected principally on the basis of their differences in water resources. Binan and Calamba have gravity systems, but only in Calamba is water available all year around. Most Cabuyao farms are irrigated by low lift pumps. The data selected for this study are from the 1965-66 cropping year when all farmers were growing local varieties, and for purposes of comparison, data from 1970-71 when farmers had planted most of their land to new varieties are also used. The survey was conducted for both wet and dry seasons. In general, the wet and dry seasons lie, respectively, at the end and beginning of a year. Thus in the Laguna data, the years 1965 and 1970 refer to the wet season, while the years 1966 and 1971 refer to the dry season. The information for these two years contains input-output data, with corresponding cost data and institutional arrangements by which costs and returns are shared among landlord, tenant, and hired laborer. The 1965-66 survey contains information on fixed capital such as plows, harrows, tractors, pumps, sprayers, weeders, and threshers. The 1970-71 survey, however, did not gather information on fixed capital.

In order to minimize changes due to sample variations, this study analyzed the data on the same 114 farms surveyed in both 1965-66 and 1970-71. Of those 114 farms, 81 had dry season crops in both periods.

Central Luzon. The original survey for 1966-67 was carried out by the Department of Agricultural Engineering at IRRI. In describing the survey Johnson et al. (1967) write:

> . . . An initial study of the Central Luzon area has been underway for over a year on a weekly sample basis to gather data on the farm operations sequence, the pattern of water use and the soil and crop conditions of these areas. In order to define the sample a preliminary observation trip was made to six of the Central Luzon provinces, Laguna, Bulacan, Nueva Ecija, Pangasinan, Tarlac and Pampanga. As a reference point

> for each sample site, kilometer posts along the major highways were used, measuring a "site" outward 25 meters from the road edge. A survey route of 800 kilometers was planned so as to require two men to travel five days per week and observe a maximum number of sites. A final survey list of 145 sites was determined consisting only of rice land. Wherever practicable, sites were selected on alternative sides of the road.
>
> Data are collected weekly on the status of each field . . . interviews are taken with the operators farming the sites. The data from this survey are compared with the weekly observations.
>
> . . . Yields of rice were obtained from as many of the sites as possible. The yield estimates are obtained by harvesting a four-square meter plot in the particular paddy being observed.
>
> . . . Data were obtained on a number of factors considered as possible determinants of yield. While these observations are important alone, the data can also be utilized in a multiple regression analysis. (Johnson et al., 1967, pp. 3-6).

The subsequent surveys for Central Luzon in 1970 and 1974 were not on the basis of weekly status of the rice fields but, similar to 1966, they did gather detailed information on input-output data, with corresponding institutional arrangements among landlords, tenants, and hired laborers. Ranade's 1974 survey collected information on fixed capital such as plows, harrows, tractors, sprayers, rotary weeders, and working animals. In 1974, a special attempt was also made to know the sex compositions of labor input and mandays of landless laborers.

Of 104 farmers in 1966, 70 remained in the sample in 1970, with six new additions in 1970. Of 76 farmers in 1970, only data for 66 farmers were collected in 1974 because some farmland was converted to other uses or because certain farmers had retired or died. Therefore, for the analysis in this section, 70 farmers were chosen from 1966, while all 76 and 66 farmers were selected from 1970 and 1974, respectively. Like the earlier analysis of Laguna, this section studies the shares of farm earnings over time for essentially the same set of farmers in Central Luzon.

Chittoor District, India

The sample of 99 households in Chittoor District, Andhra Pradesh was based on the work of a larger survey conducted in 1971. Professor Narayana conducted the earlier sample and selected six clusters of villages which were representative of Chittoor District. Doraswamy's sample was drawn from four of the six village clusters. The four determined to encompass the most variety in crop production, adoption of new technology, and proximity to market centers. Doraswamy was given the names of all farmers included in the 1971 research. He inquired of each household head as to their willingness to participate in a one-year weekly questionnaire program. If they agreed, the households were selected for the sample within that cluster of villages. If the respondent was unwilling to cooperate, additional households were selected randomly from a list provided by local officials. Of the 99 sampled households, 43 had been in the original survey, with the remaining 56 drawn from nearby households.

The four village clusters and their sample size are as follows: Madanapalle (25), Pedda Kannali (25), Chittoor (26), and Aragonda (23). Each household was visited weekly by a team of four enumerators. As project leader, Doraswamy made frequent calls on each household and debriefed enumerators on a regular basis. The assistance of Mr. O. M. Unirathnam Maidu as supervisor of the enumerators was of great help. His knowledge of the agriculture of the locale was invaluable in the formulation of questionnaires and insuring accuracy in data gathering. Professor Narayana provided valuable guidance in the conduct of this field survey and helped to place findings in a historic perspective.

Structural Characteristics of the Sample Households

Since their research concentrated on the economics of agricultural production, the studies by Ranade and Doraswamy contain little or no information about the structural and social characteristics of the farm operator households surveyed. Hart's study, which was principally concerned with the economics of household units rather than farms, does, however, contain relevant information which is presented here.

Anthropological studies of household structure in rural Java have stressed that although the nuclear household is the model organizational form, there is frequently a wide range of more complex arrangements. This is indeed the case in the study village. While 73 percent of the sample households are nuclear, the remaining 17 percent comprise six other organizational forms. The most common of these are nuclear households which include a parent of the husband or wife (8 percent), and female-headed households (8 percent) most of which have resulted from divorce. While the former type of household is more or less evenly distributed among asset groups, female-headed households tend to be concentrated in the landless class; this is the reason for the relatively high proportion of adult women in Class III households (table I.27). The generally high divorce rates in Java and Malaysia have been related to high levels of economic self-reliance of women. Hull (1976), however, has emphasized that women's economic autonomy is largely confined to the lower classes:

> The situation for the upper class woman is different; she is generally dependent on her husband for support, so that

TABLE I.27.--Inter-class Differences in Household Size and Composition, Village A, Central Java, Indonesia

	Class I	Class II	Class III
Avg. no of consumer units per household:	3.91	4.21	3.59
Avg. no. of people per household:	4.98	5.64	4.90
Percentage distribution of household members by age/ sex group:			
Children 5	12.4	17.1	16.0
Females 6-9	6.4	6.4	5.2
Males 6-9	6.4	8.3	9.6
Females 10-15	6.2	9.3	7.7
Males 10-15	10.6	10.1	10.2
Females 16+	27.9	23.3	30.3
Males 16+	30.1	25.5	21.0
Total	100.0	100.0	100.0

Source: Hart (1978), p. 111.

> in practical economic terms as well as socially, divorce is seen as having much more serious consequences for her. This relates not only to the incidence of divorce but to the pressures for remarrying. In Maguwoharjo, it was found that, even after controlling for age at marital dissolution, lower income women were more likely to remain between marriages for a longer period of time or else not to remarry at all. The large majority of these lower income women were completely self-supporting following the dissolution of marriage, except at very young ages; the few upper income women who were divorced or widowed were more likely to depend on other family members until they could remarry. (Hull, 1976, p. 47.)

It should also be borne in mind that poorer households are subjected to far higher degrees of stress, and that this is probably an important factor contributing to higher rates of marital disruption among the lower classes.

The third most common type of non-nuclear household structure is limited to the wealthiest households in Class I. It involves the household "adopting" a boy (generally between the ages of 11 and 16) to take care of water buffalo. (In table I.28, the data on years of education in parentheses excludes these children.) These children are generally from very poor households, and are provided with board and lodging, in addition to being paid a nominal allowance (about Rp5000 per year). After marriage they frequently sharecrop land from the household, and are supported in various ways. The other forms of household structure--extended families, widowers, and unrelated adults living in the household--are limited in occurrence and do not appear to be systematically related to class status.

The data on differences among age, sex, and class groups in levels of education (table I.28) must be treated with caution, as the number of observations in each cell (particularly in the lower age groups) is rather

TABLE I.28.--Inter-class Differences in Educational Levels in Village A, Central Java, Indonesia

	Years of formal education					
	Females			Males		
Age group	Class I	Class II	Class III	Class I	Class II	Class III
7 - 9	2.4	1.4	1.0	1.5	1.4	0.8
10 - 12	2.3	1.4	1.4	3.0 (3.7)[a]	2.5	2.3
13 - 15	5.0	1.7	1.6	2.3 (4.5)[a]	3.0	2.7
16 - 20	4.2	1.8	1.1	2.4 (3.4)[a]	3.2	1.8
21 - 30	3.0	2.7	0.9	3.9	3.3	2.1
31 - 40	0.3	0.5	0.1	3.0	2.6	1.6
41 - 50	0.3	0.3	0	1.0	2.0	1.6
51 +	0	0	0	2.0	0	0

Source: Hart (1978), p. 113.

[a]Figures in parentheses are years of education for nuclear household members only (see text).

small. It should also be noted that these data refer only to formal schooling, and do not include education acquired in religious schools (madrasah). There are, however, some fairly clear patterns. Among adults--particularly those over thirty--average levels of education are very low, and differences between men and women are greater than those among classes. In the case of children, however, there are some marked differences between Class I vis-a-vis Classes II and III, particularly for girls. It should be borne in mind, however, that boys from Class I households are more likely to attend madrasah, which carries high status in this strongly Islamic community.

II. PATTERNS OF HOUSEHOLD INCOME, VILLAGE A, CENTRAL JAVA, INDONESIA

Village A was specifically selected to examine the way in which landholding and income are related to annual and seasonal consumption. The village was particularly amenable to research along these lines since households with adequate land ownership to meet rice consumption requirements, households which controlled sufficient land to provide a buffer against rice shortages or high prices, and landless households could be easily differentiated. The research conducted by Hart (1978) relative to Village A was comprehensive and reveals many interesting findings. The focus was on inter-class differences in income and consumption and their relationship to assumed poverty levels. The analysis was conducted by examining household data after classification into three categories. For a discussion of these classes, see page 67. The material that follows in the next section is a synthesis of Hart's findings (1978, pp. 177-196).

Inter-Class Differences in Sources and Levels of Income

In order to facilitate comparisons among large landowners, small landowners, and the landless, data on net income and consumption at the household level have been converted to a per consumer unit basis which takes account of inter-class differences in household size and composition. Epstein (1962) uses the Lusk Coefficients, which were developed specifically in the context of a low income rural environment. This information is presented in terms of both absolute values and kilograms of milled rice equivalent--real income and consumption. The latter correct for inter-monthly variations in the rice price and allow for comparison with the poverty line of 300 kilograms of milled rice equivalent per consumer unit per year.

This poverty level is derived from the widely accepted local concept of cukupan, that 1200 kilograms of milled rice equivalent per annum is "sufficient" to satisfy the basic needs of a family of five. That is, the "poverty level" of income is accepted as being 240 kilograms of milled rice equivalent per person, with 120 kilograms being "sufficient" to cover rice needs in a rice-based diet, and the other half being sufficient for non-rice food and non-food needs. Clearly this level is obtained by averaging "needs" over different age and sex groups, and for the purposes of the present study, Hart deemed it more useful to convert the cukupan poverty level of income to a consumer unit basis in order to correct for inter-class differences in household size and composition. The coefficients used for standardizing to an adult male equivalent are a slight adaptation of those applied by Epstein (1962). The average number of persons per household in the sample is 5.17; applying the coefficients, there are an average of 3.87 "adult male equivalent" consumer units per household. Thus the minimum level of real income per consumer unit is approximately 300 kilograms of milled rice equivalent per annum, of which 150 kilograms represents rice needs.

Turning first to the source of income, it can be seen from table II.1 that major differences exist between the three classes in the percentage of income by source. In particular, there is the expected, but nevertheless dramatic, contrast between Classes I and III in the proportion of their income arising from own-production versus labor income. The respective divisions between these two sources are 77 and 7 percent for Class I, and 6 and 90 percent for Class III. Class II occupies a position roughly midway between these two. The significance of these differences is magnified when account is taken of the fact that the average income per consumer unit in Class I households is more than twice as large as that for Class II households (see figure II.1 for a graphical display of these differences by months).

It is also considered significant that the monthly data displayed in figure II.1 demonstrate that the higher incomes of Class I households exhibit much greater monthly variation than those of Class III. Hart developed the argument that this reflects the fact that poor households were forced to adopt labor allocation strategies which minimize income variance, whereas the richer Class I households had sufficient reserves for this to

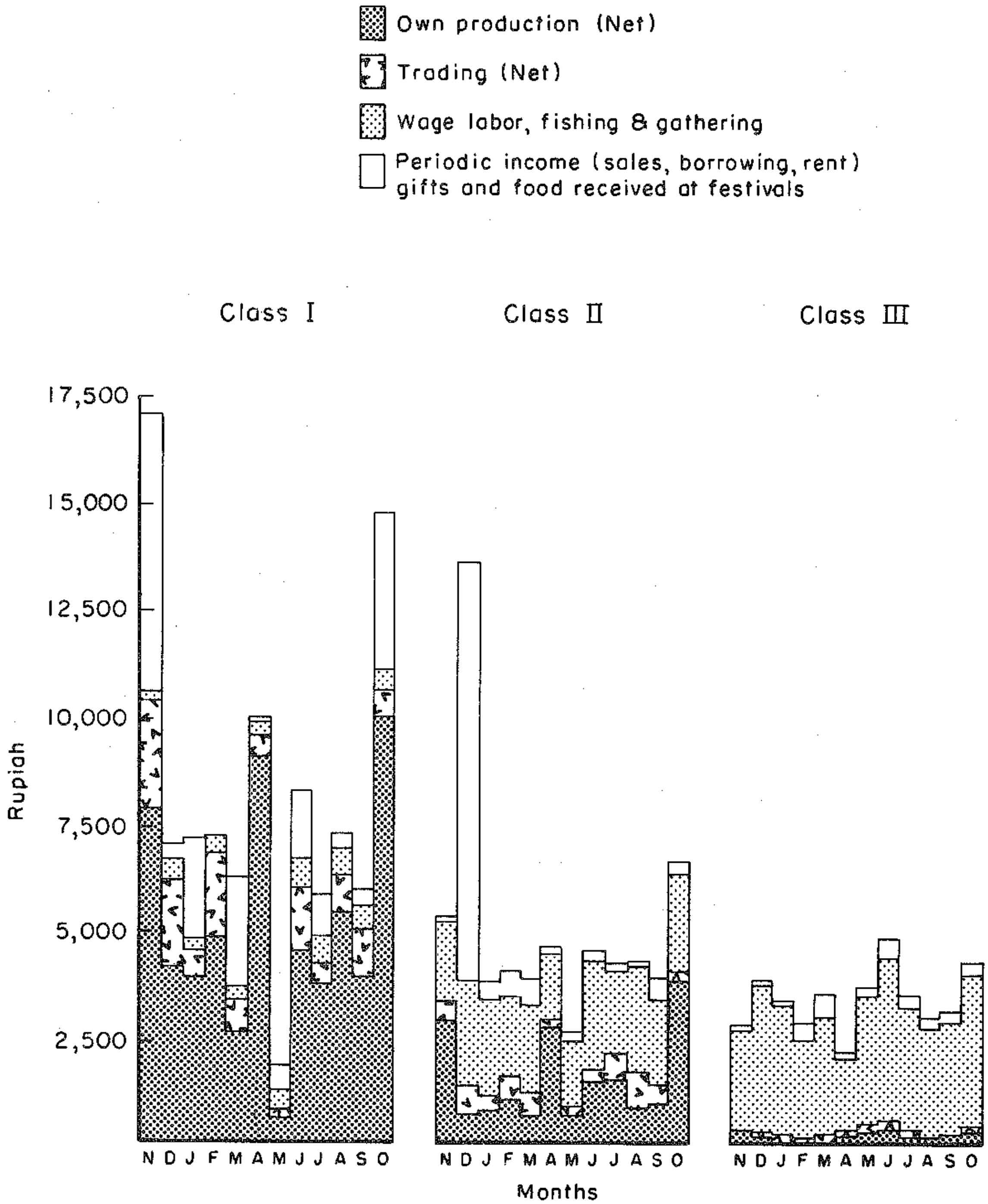
TABLE II.1.--Percent of Income by Source, Village A, Central Java, Indonesia 1976

	Own production	Trading	Manual labor[a]	Total
Class I	76.7	16.7	6.6	100
Class II	38.3	9.8	51.9	100
Class III	6.1	4.4	89.5	100

Source: Hart (1978), p. 178.

[a]This includes wage labor, fishing gathering, and home industry.

FIGURE II.1. NET INCOME BY SOURCE PER CONSUMER UNIT (ABSOLUTE VALUE), VILLAGE A, INDONESIA



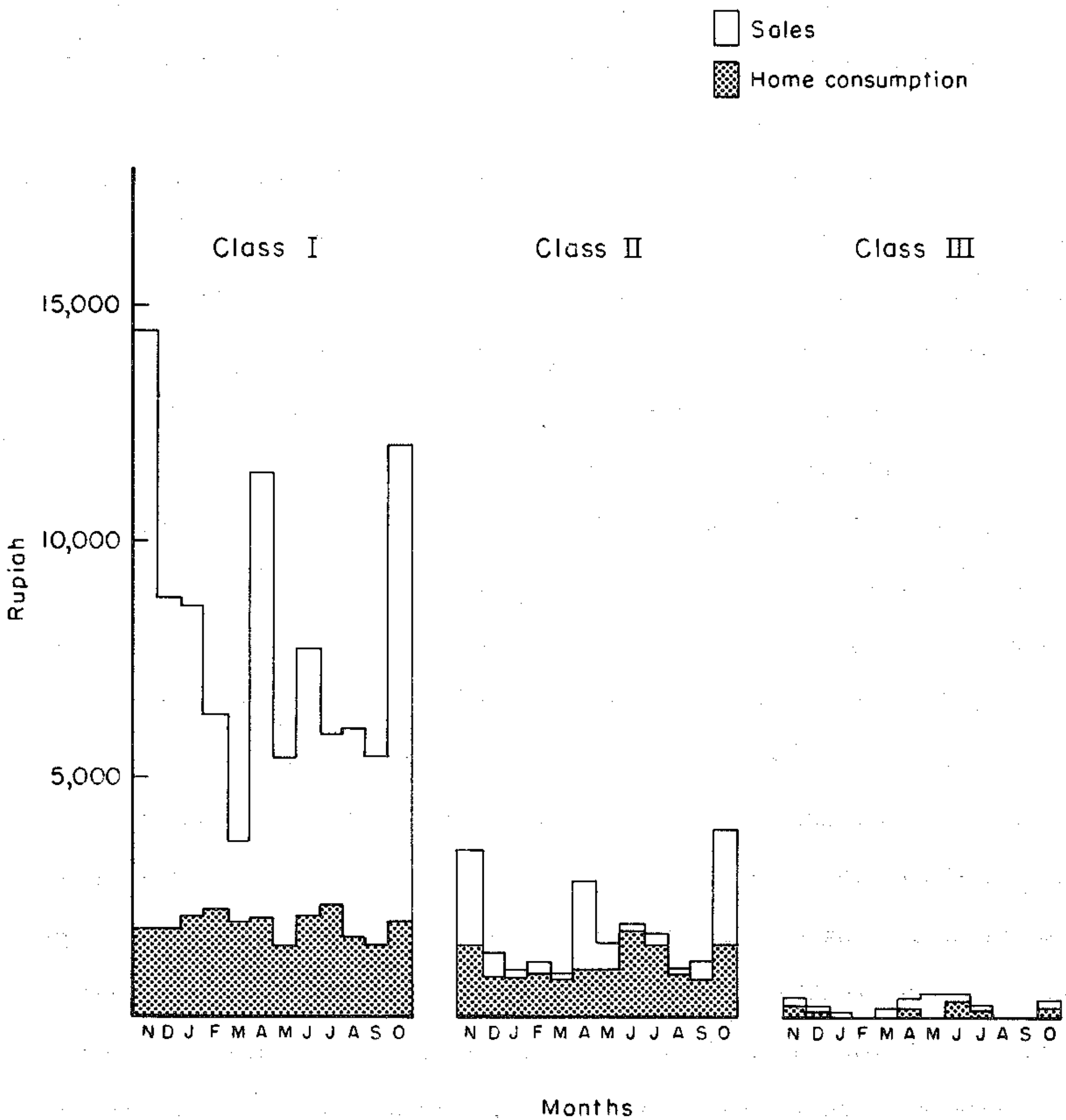
SOURCE: HART, 1978, p. 179

be relatively unimportant. Despite their higher variation of total net income, Class I households had a far more stable inflow of _cash_ throughout the year (see figure II.2), much of which is from the sale of fishpond produce and is thus limited to a subset of Class I households. There were, however, some rice sales made by Class I households in post-harvest months when the rice price was increasing. The extent to which those in Class II sold rice was limited to a few households which, because of immediate cash needs, sold their rice to a middleman (_penebas_) prior to the harvest.

Several of the largest landowning households were also involved in _tebasan_ selling, that is, selling the crop to a "contract harvester" who thereby acquires ownership of the grain. This group, however, only sold a portion of its rice in this manner and harvested a sufficient amount to cover consumption needs. While prices received in _tebasan_ sales tend to be somewhat below the market price of paddy, this type of transaction provides a quick and assured return, and enables the operator to avoid giving harvest shares. For these and other reasons the net return from _tebasan_ sales is frequently higher than that from sales of harvested rice. However, Class I households hire a large proportion of labor for pre-harvest operations, and thus incur higher per hectare costs. The sharp drop in the average net income of Class I in May (figure II.1) is attributable to extensive outlays for labor and other inputs at the commencement of the dry season cropping cycle.

The bulk of income received by the landless class is in the form of cash wages, and the income fluctuations which they experience derive from

FIGURE II.2. GROSS INCOME FROM OWN PRODUCE PER CONSUMER UNIT: SALES AND HOME CONSUMPTION, VILLAGE A, INDONESIA



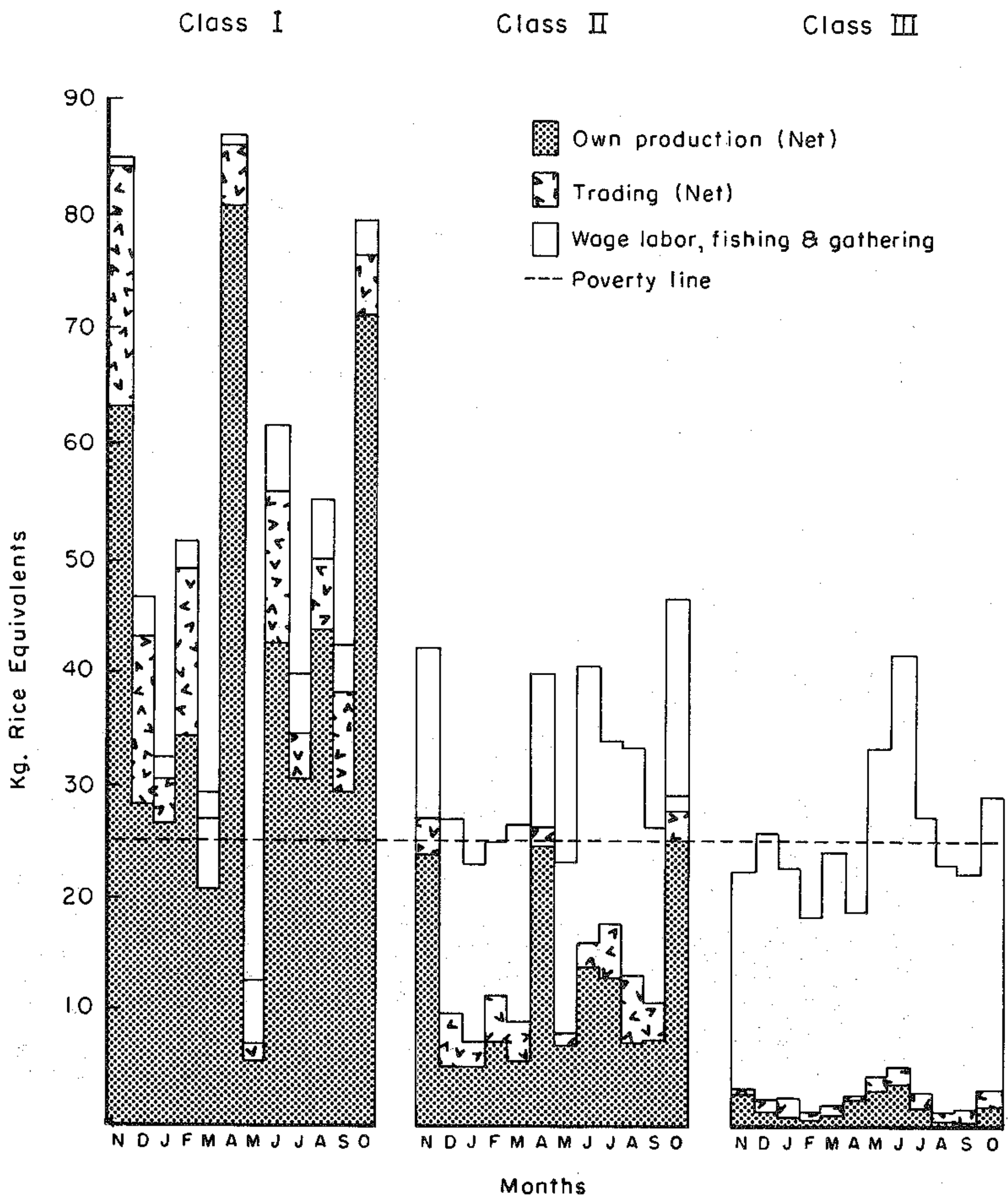
SOURCE: HART, 1978, p. 181

variations in returns to labor relative to labor time. Contrary to commonly held views, the big wet season harvest is not a remunerative period for the landless in this village. Correcting (by converting income to rice equivalents) for the relatively low rice price in this period, figures II.3 and II.4 show that both the income and consumption of landless households were at their lowest levels in April. It is a cruel irony that even in this period of relatively low rice prices and peak labor demand, the real income of landless households did not allow for the purchase of extra rice or savings in the form of cash against other stress times of the year. Low wage rates in August and September also depress labor income--despite very long work duration--in these months.

Income not directly related to off-farm labor and production activities constitutes the fourth category depicted in figure II.1. It includes food received at feasts and gifts (most of which are in the form of food), as well as "periodic income," defined as sales of assets and household possessions, consumption borrowing, and rent receipts. Households rarely borrow directly for consumption purposes. A poor household unable to meet its needs from work income is far more likely to pawn possessions at the nearby government pawnshop, or to sell chickens. In landless households the pawning or selling of possessions is indicative of extreme hardship; these critical periods are most marked in February and March when floods frequently curtail work opportunities. The very high levels of periodic income received by Class I in November and Class II in December, represent sales of major production assets by one or two households.

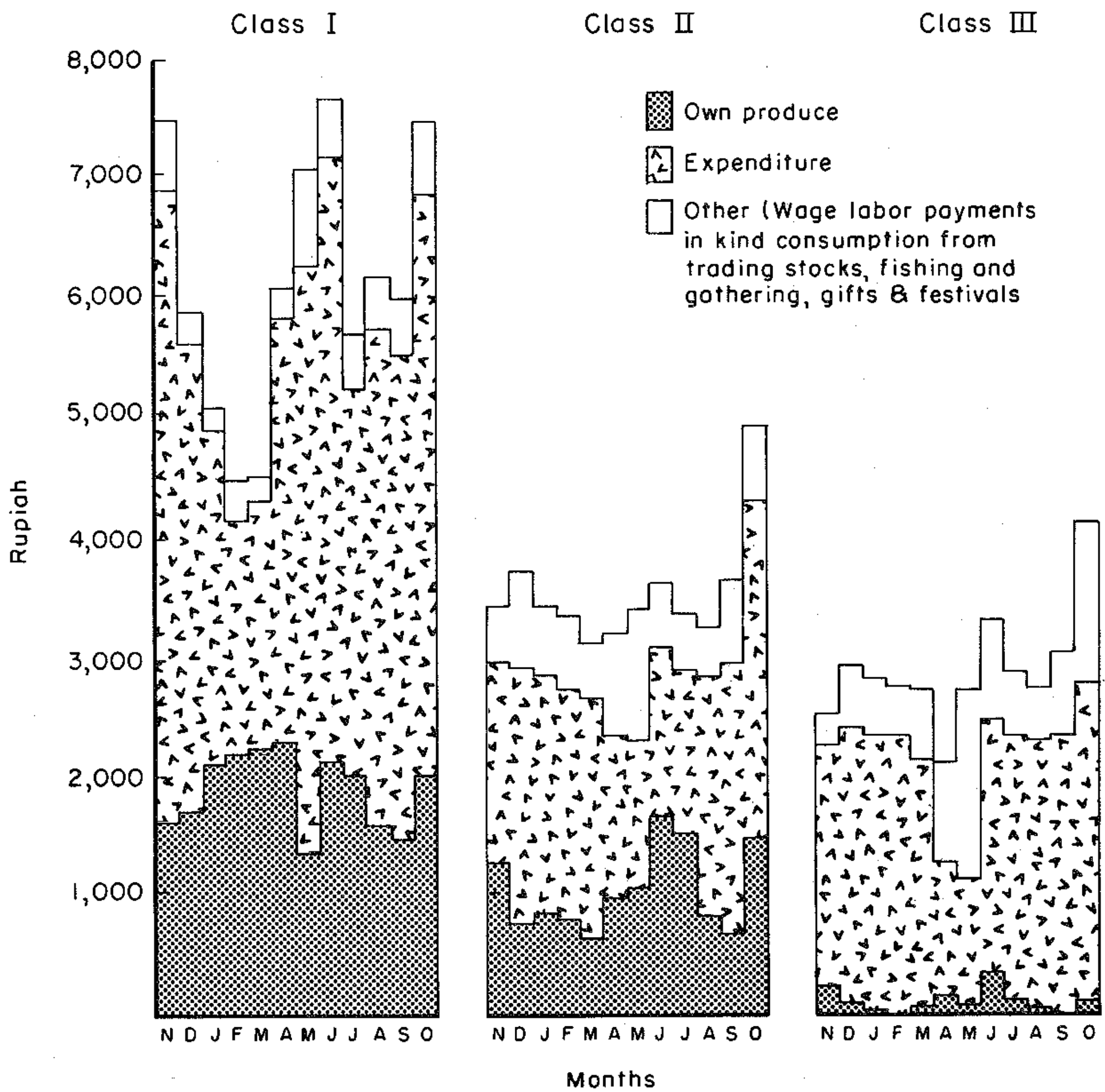
Periodic income thus distorts the average, and is excluded from figure II.3 which shows monthly variations in net income in milled rice

FIGURE II 3. INCOME BY SOURCE IN RICE EQUIVALENTS PER CONSUMER UNIT (EXCLUDING PERIODIC INCOME), VILLAGE A, INDONESIA



SOURCE: HART, 1978, p. 184

FIGURE II.4. VALUE OF CONSUMPTION BY SOURCE PER CONSUMER UNIT, VILLAGE A, INDONESIA



SOURCE: HART, 1978, p. 187

equivalents. This figure demonstrates clearly the higher average level, together with the far greater variability, in real net income of Class I relative to that of Classes II and III. At first glance, the real income levels of Classes II and III do not appear very different. If, however, they are viewed in terms of the poverty line--25 kg milled rice equivalent per consumer unit per month--this superficially small difference assumes major importance. Class II households fell below the poverty level in two months of the year; May was a period of relatively high production costs, while some sales of produce had been made in April. The average landless household's income only went above the poverty line in five months, four of which coincided with periods of peak labor damand, when both wage rates and job opportunities were comparatively high. Total annual net income in kilograms of rice equivalents (excluding periodic income, gifts, and food received at feasts) for each of the three classes is as follows:

Class I	622.9
Class II	385.8
Class III	306.9

The question now arises as to what these data mean in terms of consumption and welfare.

Patterns of Consumption by Asset Classes

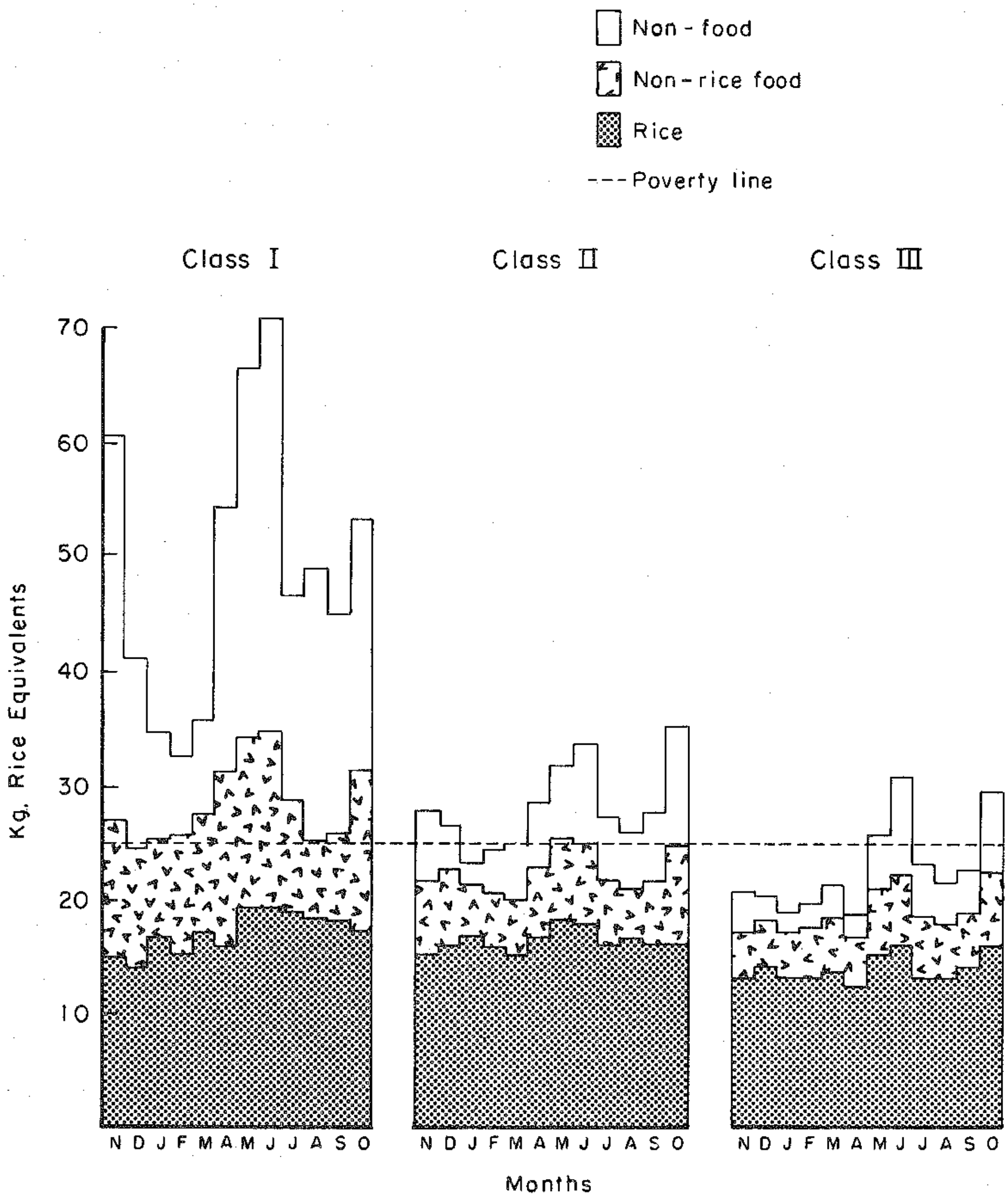
While landless households are, on average, slightly above the poverty line in terms of income, their consumption falls short of the minimum acceptable level by almost 10 percent. Over the whole year, average consumption of all items per consumer unit in kilograms of milled rice equivalent for each of the three classes was as follows:

Class I	590.1
Class II	335.4
Class III	274.0

A very interesting feature which emerges on comparing these consumption figures to those on income, is that all three classes appear to save, and that the savings in Class III are of the same magnitude as those in Class I--Class II households apparently saved more than the others. If the possibility that these savings are a product of a lag between the income and consumption streams is discounted, why should Class III households living on the poverty margin allow their consumption to fall below the 300 kilograms of rice poverty frontier by saving some of their income? The answer lies, in part, in inter-class differences in the source and allocation of consumption, which will be explored in the remainder of this section. More fundamentally, it derives from the set of forces which constrain the household when it has no physical assets to fall back on.

Inter-class differences in the levels of consumption depicted in figures II. 4 and II.5 are related to income patterns. There is a direct

FIGURE II.5 . ALLOCATION OF CONSUMPTION AMONG RICE, NON-RICE FOOD AND NON-FOOD: RICE EQUIVALENTS FOR CONSUMER UNIT, VILLAGE A, INDONESIA



SOURCE: HART, 1978, p. 188

relationship between asset class and consumption, but the difference between large and small landholding households is far greater than that between small landowners and the landless. The level of consumption in Class I is also far more subject to seasonal variation than that of Classes II and III. (The lebaran festival marking the end of the Moslem fasting month fell in the October interview periods; hence the comparatively high levels of consumption in all three classes in this month.) There is, however, a very significant divergence between Classes II and III in terms of the proportion of consumption derived from different sources. The relative importance of each source of consumption for the three classes over the whole year is shown in table II.2. It can be seen that the proportion of consumption derived from own-produce for both Classes I and II is virtually identical, at 30 percent; while the landless group is the most heavily reliant, to the extent of 72 percent, on market purchased consumption goods. The extremely small proportion of consumption of own-produce in Class III assumes added significance if viewed in terms of inter-class differences in the allocation of consumption between rice and other commodities. This emerges clearly from figure II.5, which shows the manner in which each of the three classes allocate their consumption among rice, non-rice food, and non-food in each month, as well as from the data in table II.3 which summarize allocation of consumption (in milled rice equivalents) for the whole year. What these data demonstrate is a classic example of Engels Law, in that rice consumption rises much less than the proportionate rise in income as one moves from Class III to Class I, while the proportion of income devoted to non-food rises appreciably.

TABLE II.2.--Percentage of Consumption Derived from Different Sources, Village A, Central Java, Indonesia

	Own produce	Purchases	Wage labor[a]	Trading stocks	Fishing & gathering	Gifts & festivals	Total
Class I	30.4	62.5	1.3	1.8	0.5	3.5	100
Class II	29.9	52.2	6.7	3.4	3.9	3.9	100
Class III	4.1	71.6	14.5	1.8	4.5	3.5	100

Source: Hart (1978), p. 186.

[a]i.e., payments in kind.

TABLE II.3.--The Allocation of Consumption to Rice, Other Food and Non-Food Items (Kg. Milled Rice Equivalents), Village A, Central Java, Indonesia

	Rice					
	Basic sources[a]	Other[b]	Total	Other food	Non-food	Total
Class I	189.0	16.5	205.6	134.5	250.0	590.1
			(34.8%)	(22.8%)	(42.4%)	(100%)
Class II	178.4	16.5	194.9	66.3	74.6	335.8
			(58.0%)	(19.7%)	(22.3%)	(100%)
Class III	150.1	18.1	168.2	58.1	47.7	274.0
			(61.4%)	(21.2%)	(17.4%)	(100%)

Source: Hart (1978), p. 189.

[a]Own produce, purchased rice, and harvest shares.

[b]The rice component of payments in kind for wage labor, food received at festivals and gifts; this has been estimated at 70 percent.

The fact that even the poorest households consumed an average of 168 kilos of rice per consumer unit (table II.3), while Classes II and III consumed 195 and 206 kilos, respectively, sheds a particularly interesting light on the meaning of the poverty line. As was mentioned earlier, the poverty line is constructed on the assumption that 50 percent of the total--120 kilograms of milled rice per capita, or 150 kilos per adult male equivalent consumer unit--covers rice needs in a rice-based diet. Hanna (1976) has suggested that the preferred level of rice consumption is nearer 180 kilograms per capita, which is over 200 kilograms per consumer unit. The data from this survey strongly confirm Hanna's argument that the generally accepted poverty line is very low indeed, since given the preferred level of rice consumption, it leaves less than 50 percent for other items. Certainly, if it is accepted that the official estimate of 150 kilograms of milled rice equivalent per consumer unit per year represents an acceptable minimum for non-rice consumption, the average landless household falls short by almost 50 percent.

The serious nutritional implications of this will be demonstrated below in the discussion of non-rice food consumption. One must, however, first consider the manner in which different asset groups procure rice, the supremely important source of food energy which dominates not only the Javanese economy, but the whole setting within which people live and work and make offerings to Dewi Sri, the rice goddess, in spite of their devout belief in the Islamic faith.

The information in table II.4 is a powerful illustration of the fundamental difference between a household which controls even a small

TABLE II.4.--Proportion of Rice Consumption from Basic Sources: Annual Average, Village A, Central Java, Indonesia

	Own produce	Purchased	Harvest share	Total
Class I	80.7	18.6	0.7	100
Class II	56.2	37.4	6.4	100
Class III	7.1	75.6	17.3	100

Source: Hart (1978), p. 192.

piece of land, and one which has no access to land. Whereas households in Class II purchased only 37 percent of their rice, those in Class III had to purchase 76 percent (with the bulk of the remainder received as payment-in-kind for labor). The implications of this for the social impact of changes in rice price are quite stark, especially when it is noted that 43 percent of households in Village A are classified in Class III. It is clear that those in Class III who devote a high proportion of total income to purchasing rice will suffer from a rise in the price of rice, while whose (particularly in Class I) who produce surplus rice which can be allocated to the purchase of other foods and non-foods will clearly gain. Thus increases in the price of rice will exacerbate real income differences between classes.

The importance of the average landless household having to buy 76 percent of the rice it consumes cannot be overemphasized, and is closely related to labor allocation behavior. One of the central hypotheses to emerge from Hart's study, and one which has far-reaching policy implications, is that dependence of landless households on market-purchased rice is the key factor determining their preference for low wage but stable jobs, particularly in the slack season. Conversely, the buffer provided to small landowning households by being able to produce a large proportion of their rice needs enables them to avoid having to accept unfavorable off-farm work.

An interesting feature which underlies the data in table II.4 is that the monthly average level of total rice consumption of the landless class is not only relatively low, but it scarcely varies at all throughout the year. The average level of 12.5 kilograms per month is, furthermore, identical with the minimum defined by the poverty line and amounts to approximately 1450 calories per adult male equivalent per day. In contrast, the average adult male equivalent in Classes II and I consumes in the vicinity of 1900 and 2000 calories per day, respectively. This is particularly notable in view of the inverse relationship between asset status and the duration and arduousness of labor. A crucial issue--which these data cannot, unfortunately, address--is the intrahousehold allocation of consumption, given the high involvement of landless women and children in heavy physical work.

The greatest disparity in consumption among classes is in non-food consumption (figure II.5). As assets rise, households increase their expenditures on tobacco, fuel, cleaning materials, health services, medicine, and education substantially; they also establish closer material contact with other households, as evidenced by increasing expenditures on gifts and festivals. While it was beyond the scope of Hart's study to explore the implications of these patterns, it is very likely that they are indicative of important reciprocal ties which carry over into labor relationships and access to land and credit.

The Relationship Between Income and Consumption

With the income, price, and expenditure/consumption data collected, Hart was able to undertake formal demand analysis for the sample households. Such studies for rural households in developing countries are comparatively rare, and Hart's results are even more interesting because of this. Since monthly price and expenditure/consumption data were available, the demand analysis conducted was a pooled cross-section with time-series variety, thus enabling both income and price influences on consumption/expenditure to be examined. The cross-sectional element involved using data for all sample households (not differentiated by class), while the time series was provided by expressing the household data on a monthly basis for the 12 months of the survey period. Rather than pooling the data for the full twelve months, the data were subdivided and analyzed according to the following set of periods:

Wet season peak labor demand -- November to January
Wet season slack period -- February, March
Wet season harvest -- April
Dry season peak labor demand -- May to July
Dry season slack period -- August to October

This subdivision allowed for major differences in the state of the village economy as reflected in seasonal levels of employment, food availability, and rice prices. The method of analysis used involved disaggregating total "expenditure" (including consumption from own-production and of payments-in-kind) into three categories, rice, non-rice food, and non-food. Multinomial logit analysis was then employed to analyze the allocational response of household shares of total "expenditures" for these three categories in response to changes in (1) average annual income per consumer unit, (2) monthly rice prices per household, and (3) changes in the ratio of adults (potential workers) to consumer units. The main virtues of using multinomial logit for this purpose are that it ensures that the different "expenditure" shares add up to one at all levels of the explanatory variables, while simultaneously allowing the budget shares and elasticities to change non-linearly with respect to the various explanatory variables.

The actual regression results are presented in table II.5. Only the economic implications of the results will be discussed here; these are presented in detail in tables II.6-II.11. The statistical properties of multinomial logit analysis are particularly well illustrated in tables II.7-II.11. The economic behavior implied by the statistical estimates is in no way surprising, and largely confirms accepted assumptions about demand behavior in poor rural communities. However, because of the relative scarcity of empirical support for these assumptions, especially in the detail provided by Hart's application, discussion is clearly merited.

In the first place, the results confirm (table II.6) expectations that the income elasticity of demand for rice is appreciably less elastic than those for "other foods" and "non-food." At the mean values of the explanatory variables, the income elasticity of demand for rice varies between 0.48 and 0.71, depending upon the season, and appears to average

TABLE II.5.--Estimates of the Multinomial Logit Budget Allocation Model for Rice, Other Food, and Nonfood Items, Village A, Central Java, Indonesia

Season (months)	Dependent variable: In[(Er+Cr)/In Eo]				
	Constant	In (M/H)	In (Pr)	(Nf+Nm)/H	$\bar{R}^2$
Wet season peak	4.108	-0.996	1.159	-0.781	0.45
(Nov/Dec/Jan)		(12.54)	(5.41)	(3.46)	
Wet season slack	-0.019	-0.513	1.148	-0.570	0.40
(Feb/Mar)		(5.67)	(10.13)	(2.82)	
Wet season harvest	-1.113	-0.289	1.008	-0.440	0.34
(April)		(2.64)	(6.63)	(1.26)	
Dry season peak	0.311	-0.435	0.978	-0.573	0.18
(May/June/July)		(6.59)	(3.21)	(3.13)	
Dry season slack	2.518	-0.546	0.674	-0.436	0.26
(Aug/Sept/Oct)		(7.79)	(3.95)	(2.42)	

TABLE II.5.--Cont.

Season	Dependent variable: In[(Er+Cr)/In En]					
(months)	Constant	In (M/H)	In (Pr)	(Nf+Nm)/H	$\bar{R}^2$	n
Wet season peak	4.315	-1.478	1.965	-0.746	0.51	253
(Nov/Dec/Jan)		(14.21)	(6.96)	(2.51)		
Wet season slack	1.934	-0.931	1.522	-0.636	0.46	170
(Feb/Mar)		(8.03)	(10.49)	(2.45)		
Wet season harvest	3.480	-1.138	1.505	-0.358	0.55	85
(April)		(8.40)	(7.96)	(0.83)		
Dry season peak	5.279	-1.246	1.217	-0.312	0.48	274
(May/June/July)		(15.54)	(3.28)	(1.40)		
Dry season slack	9.241	-1.538	0.912	-0.344	0.58	272
(Aug/Sept/Oct)		(18.01)	(4.38)	(1.57)		

Source: Hart (1978), p. 239.

Note: Parentheses contain the ratio of the coefficient to its standard error.

Er = value of own produced rice; Cr = value of own produced rice consumed; Er + Cr = "expenditure" on rice; Eo = expenditure on other food; En = expenditure on non-food; Pr = price of rice; M = total nominal annual income/household; Nf = number of adult females/household; Nm = number of adult males/household; H = number of consumer units/household.

TABLE II.6.--Elasticities and Budget Shares Computed at the Means, Village A, Central Java, Indonesia

Season	Mean values[a]	Elasticities			Budget shares		
		Rice	Other food	Non-food	Rice	Other food	Non-food
Wet season peak	M/H = 4000 Pr = 138 N/H = 0.776	0.50 -0.37 -0.25	1.50 -0.53 0.36	1.98 -1.34 0.34	0.59	0.23	0.18
Wet season slack	M/H = 4000 Pr = 133 N/H = 0.776	0.71 -0.45 -0.19	1.22 -0.60 0.25	1.64 -0.97 0.29	0.58	0.24	0.18
Wet season harvest	M/H = 4000 Pr = 113 N/H = 0.776	0.68 -0.43 -0.14	0.96 -0.44 0.20	1.81 -0.94 0.14	0.55	0.22	0.23
Dry season peak	M/H = 4000 Pr = 113 N/H = 0.776	0.53 -0.43 -0.16	0.96 -0.40 0.28	1.77 -0.64 0.08	0.49	0.20	0.31
Dry season slack	M/H = 4000 Pr = 133 N/H = 0.776	0.48 -0.62 -0.14	1.02 -0.29 0.20	2.01 -0.53 0.13	0.53	0.20	0.27

Source: Hart (1978), p. 240.

[a]M/H is the value of total consumption (expenditure) per consumer unit; Pr is the mean price per kilogram of milled rice for that set of months (both in Rupiah); and N/H is the average ratio of potential workers (people over the age of ten) to total consumer units.

TABLE II.7.--Sensitivity Analysis of Budget Shares and Elasticities with Respect to the Total Value of Consumption: High Price Period (Wet Season Peak), Village A, Central Java, Indonesia

	Rice		Other food		Nonfood	
M/H[a]	Budget share	Elas-ticity	Budget share	Elas-ticity	Budget share	Elas-ticity
1000.00	0.88	0.86	0.08	1.86	0.03	2.34
1400.00	0.83	0.80	0.11	1.80	0.05	2.28
1800.00	0.79	0.75	0.14	1.75	0.07	2.23
2200.00	0.74	0.70	0.16	1.69	0.10	2.18
2600.00	0.70	0.65	0.18	1.65	0.12	2.13
3000.00	0.67	0.60	0.19	1.60	0.14	2.08
3400.00	0.63	0.56	0.21	1.56	0.16	2.04
3800.00	0.60	0.52	0.22	1.52	0.17	2.00
4200.00	0.57	0.48	0.23	1.48	0.19	1.96
4600.00	0.55	0.45	0.24	1.44	0.21	1.92
5000.00	0.52	0.41	0.25	1.41	0.23	1.89
5400.00	0.50	0.38	0.26	1.38	0.24	1.86
5800.00	0.47	0.35	0.26	1.35	0.26	1.83
6200.00	0.45	0.32	0.27	1.32	0.27	1.80
6600.00	0.44	0.30	0.28	1.30	0.29	1.78
7000.00	0.42	0.28	0.28	1.27	0.30	1.75
7400.00	0.40	0.25	0.29	1.25	0.31	1.73
7800.00	0.39	0.23	0.29	1.23	0.32	1.71
8200.00	0.37	0.21	0.29	1.21	0.34	1.69
8600.00	0.36	0.19	0.29	1.19	0.35	1.67
9000.00	0.34	0.17	0.30	1.17	0.36	1.65
9400.00	0.33	0.16	0.30	1.15	0.37	1.63
9800.00	0.32	0.14	0.30	1.14	0.38	1.62
10200.00	0.31	0.12	0.30	1.12	0.39	1.60
10600.00	0.30	0.11	0.30	1.11	0.40	1.59

Source: Hart (1978), p. 244.

[a]Total value of consumption per consumer unit (in Rupiah).

TABLE II.8.--Sensitivity Analysis of Budget Shares and Elasticities with Respect to the Total Value of Consumption: Low Price Period (Dry Season Peak), Village A, Central Java, Indonesia

M/H[a]	Rice		Other food		Nonfood	
	Budget share	Elasticity	Budget share	Elasticity	Budget share	Elasticity
1000.00	0.71	0.78	0.16	1.21	0.12	2.02
1400.00	0.66	0.71	0.17	1.14	0.17	1.96
1800.00	0.60	0.65	0.18	1.09	0.22	1.90
2200.00	0.56	0.60	0.18	1.03	0.26	1.84
2600.00	0.52	0.55	0.18	0.99	0.30	1.80
3000.00	0.49	0.51	0.18	0.94	0.33	1.75
3400.00	0.46	0.47	0.18	0.90	0.36	1.71
3800.00	0.43	0.43	0.17	0.87	0.39	1.68
4200.00	0.41	0.40	0.17	0.84	0.42	1.65
4600.00	0.38	0.37	0.17	0.81	0.44	1.62
5000.00	0.36	0.34	0.17	0.78	0.47	1.59
5400.00	0.35	0.32	0.16	0.75	0.49	1.56
5800.00	0.33	0.29	0.16	0.73	0.51	1.54
6200.00	0.31	0.27	0.16	0.71	0.53	1.52
6600.00	0.30	0.25	0.15	0.69	0.54	1.50
7000.00	0.29	0.23	0.15	0.67	0.56	1.48
7400.00	0.27	0.22	0.15	0.65	0.57	1.46
7800.00	0.26	0.20	0.15	0.64	0.59	1.45
8200.00	0.25	0.19	0.14	0.62	0.60	1.43
8600.00	0.24	0.17	0.14	0.61	0.61	1.42
9000.00	0.23	0.16	0.14	0.59	0.62	1.40
9400.00	0.23	0.15	0.14	0.58	0.64	1.39
9800.00	0.22	0.13	0.13	0.57	0.65	1.38
10200.00	0.21	0.12	0.13	0.56	0.66	1.37
10600.00	0.20	0.11	0.13	0.55	0.67	1.36

Source: Hart (1978), p. 245.

[a]Total value of consumption per consumer unit (in Rupiah).

TABLE II.9.--Sensitivity Analysis of Budget Shares and Elasticities with Respect to the Price of Rice: Low Income Group, Village A, Central Java, Indonesia

Rice Price	Rice		Other food		Nonfood	
	Budget share	Elas-ticity	Budget share	Elas-ticity	Budget share	Elas-ticity
80.00	0.60	-0.53	0.26	-0.54	0.14	-1.04
88.00	0.63	-0.56	0.24	-0.57	0.12	-1.07
96.00	0.65	-0.59	0.23	-0.60	0.11	-1.10
104.00	0.67	-0.62	0.22	-0.63	0.10	-1.12
112.00	0.69	-0.64	0.21	-0.65	0.09	-1.15
120.00	0.71	-0.66	0.20	-0.67	0.09	-1.17
128.00	0.72	-0.68	0.19	-0.69	0.08	-1.19
136.00	0.74	-0.70	0.18	-0.71	0.08	-1.20
144.00	0.75	-0.71	0.18	-0.72	0.07	-1.22
152.00	0.76	-0.73	0.17	-0.73	0.07	-1.23
160.00	0.77	-0.74	0.16	-0.75	0.06	-1.24
168.00	0.78	-0.75	0.16	-0.76	0.06	-1.26
176.00	0.79	-0.76	0.15	-0.77	0.05	-1.27
184.00	0.80	-0.77	0.15	-0.78	0.05	-1.28
192.00	0.81	-0.78	0.14	-0.79	0.05	-1.29
200.00	0.81	-0.79	0.14	-0.80	0.05	-1.29
208.00	0.82	-0.80	0.13	-0.80	0.04	-1.30
216.00	0.83	-0.80	0.13	-0.81	0.04	-1.31
224.00	0.83	-0.81	0.13	-0.82	0.04	-1.32
232.00	0.84	-0.82	0.12	-0.83	0.04	-1.32
240.00	0.84	-0.82	0.12	-0.83	0.04	-1.33
248.00	0.85	-0.83	0.12	-0.84	0.03	-1.33
256.00	0.85	-0.83	0.11	-0.84	0.03	-1.34
264.00	0.86	-0.84	0.11	-0.85	0.03	-1.34
272.00	0.86	-0.84	0.11	-0.85	0.03	-1.35

Source: Hart (1978), p. 250.

TABLE II.10.--Sensitivity Analysis of Budget Shares and Elasticities with Respect to the Price of Rice: Medium Income Group, Village A, Central Java, Indonesia

Rice Price	Rice		Other food		Nonfood	
	Budget share	Elas-ticity	Budget share	Elas-ticity	Budget share	Elas-ticity
80.00	0.44	-0.28	0.25	-0.29	0.31	-0.79
88.00	0.47	-0.32	0.24	-0.33	0.28	-0.83
96.00	0.50	-0.36	0.23	-0.37	0.26	-0.87
104.00	0.52	-0.40	0.23	-0.40	0.25	-0.90
112.00	0.55	-0.43	0.22	-0.44	0.23	-0.93
120.00	0.57	-0.46	0.21	-0.47	0.22	-0.96
128.00	0.59	-0.48	0.21	-0.49	0.20	-0.99
136.00	0.61	-0.51	0.20	-0.52	0.19	-1.01
144.00	0.62	-0.53	0.19	-0.54	0.18	-1.04
152.00	0.64	-0.55	0.19	-0.56	0.17	-1.06
160.00	0.65	-0.57	0.18	-0.58	0.16	-1.08
168.00	0.67	-0.59	0.18	-0.60	0.15	-1.09
176.00	0.68	-0.60	0.17	-0.61	0.14	-1.11
184.00	0.69	-0.62	0.17	-0.63	0.14	-1.13
192.00	0.70	-0.63	0.16	-0.64	0.13	-1.14
200.00	0.71	-0.65	0.16	-0.66	0.12	-1.15
208.00	0.72	-0.66	0.16	-0.67	0.12	-1.17
216.00	0.73	-0.67	0.15	-0.68	0.11	-1.18
224.00	0.74	-0.68	0.15	-0.69	0.11	-1.19
232.00	0.75	-0.69	0.14	-0.70	0.10	-1.20
240.00	0.76	-0.70	0.14	-0.71	0.10	-1.21
248.00	0.76	-0.71	0.14	-0.72	0.10	-1.22
256.00	0.77	-0.72	0.13	-0.73	0.09	-1.23
264.00	0.78	-0.73	0.13	-0.74	0.09	-1.23
272.00	0.78	-0.74	0.13	-0.75	0.09	-1.24

Source: Hart (1978), p. 251.

TABLE II.11.--Sensitivity Analysis of Budget Shares and Elasticities with Respect to the Price of Rice: High Income Group, Village A, Central Java, Indonesia

	Rice		Other food		Nonfood	
Rice Price	Budget share	Elas-ticity	Budget share	Elas-ticity	Budget share	Elas-ticity
80.00	0.35	-0.13	0.23	-0.14	0.42	-0.64
88.00	0.38	-0.17	0.22	-0.18	0.40	-0.68
96.00	0.40	-0.21	0.22	-0.22	0.37	-0.72
104.00	0.43	-0.25	0.22	-0.26	0.35	-0.76
112.00	0.45	-0.28	0.21	-0.29	0.33	-0.79
120.00	0.48	-0.32	0.21	-0.32	0.31	-0.82
128.00	0.50	-0.35	0.20	-0.35	0.30	-0.85
136.00	0.52	-0.37	0.20	-0.38	0.28	-0.88
144.00	0.54	-0.40	0.19	-0.41	0.27	-0.90
152.00	0.55	-0.42	0.19	-0.43	0.26	-0.93
160.00	0.57	-0.44	0.18	-0.45	0.24	-0.95
168.00	0.58	-0.47	0.18	-0.47	0.23	-0.97
176.00	0.60	-0.49	0.18	-0.49	0.22	-0.99
184.00	0.61	-0.50	0.17	-0.51	0.21	-1.01
192.00	0.63	-0.52	0.17	-0.53	0.20	-1.03
200.00	0.64	-0.54	0.16	-0.55	0.19	-1.04
208.00	0.65	-0.55	0.16	-0.56	0.19	-1.06
216.00	0.66	-0.57	0.16	-0.58	0.18	-1.07
224.00	0.67	-0.58	0.15	-0.59	0.17	-1.09
232.00	0.68	-0.59	0.15	-0.60	0.17	-1.10
240.00	0.69	-0.61	0.15	-0.62	0.16	-1.11
248.00	0.70	-0.62	0.15	-0.63	0.15	-1.12
256.00	0.71	-0.63	0.14	-0.64	0.15	-1.14
264.00	0.71	-0.64	0.14	-0.65	0.14	-1.15
272.00	0.72	-0.65	0.14	-0.66	0.14	-1.16

Source: Hart (1978), p. 252.

around 0.55. In contrast, the average income elasticity of demand for "non-food" is high, at around 1.8 (with a seasonal range from 1.64 to 2.01), while that for non-rice food is estimated to average about 1.15. The relative magnitudes of the expenditure elasticities of the three categories with respect to the rice price tend to reflect their income elasticities. The "own price" elasticity of expenditure on rice, at approximately -0.45, is substantially less elastic than that for "non-food" with respect to the rice price, which is estimated at about -0.9.

More interesting than the average elasticities, however, is the information the results generate about the ways in which the elasticities and budget (expenditure) shares change in response to changes in the levels of income and rice prices. Table II.7, for example, reveals the changes in these parameters as household income per consumer unit varies through the range 1,000 to 10,600 rupiah in the wet season peak. For a family at the lowest end of this income range, the income elasticity of demand for rice is estimated to be 0.86 and its expenditure share 0.88; for a comparable family with 5,400 rupiahs per consumer unit, these values are estimated to fall to 0.38 and 0.50, respectively; and at 10,600 rupiahs, to 0.11 and 0.30. Thus, the income elasticity of demand for rice falls rapidly (and nonlinearly), with its expenditure share dropping less rapidly. The expenditure shares of "other foods" and "non-food" are estimated to increase over the same income range, although their income elasticities naturally decline. Nevertheless, "other food" and (not surprisingly) "non-food" retain income elasticities of demand greater than one over the whole income range explored. Table II.8 presents similar data for the dry season.

Some readers may wish to contrast elasticities between these distinctly different seasons. In general, elasticities for rice are lower for all income classes during the dry season.

Turning to the comparable analysis of changes in elasticities of demand with respect to the rice price and the associated expenditure (budget) shares as prices increase, only the case of the low income group of households will be discussed. The results of this exercise are reproduced in table II.9 (and those for medium and high income households in the following two tables). As expected on theoretical grounds, as the rice price rises the price elasticity of demand for all three categories also rises. But what is of most interest is to see how the budget share for rice rises in response to increases in its price, while the shares of the other two categories decline. Thus, at a price of 80 rupiahs per kilo of milled rice, only 60 percent of a low income family's budget would be spent on rice, with 26 percent and 14 percent being allocated to "other food" and "non-food," respectively. At a price of 272 rupiahs per kilo the situation would be very different, with 86 percent of expenditure being allocated to rice and expenditures in the other two categories being squeezed to 11 and 3 percent, respectively. Tables II.10 and II.11 reveal a similar, although slightly less severe, pattern for medium and high income households. But this similarity is misleading, for the calculations are made at fixed income levels, whereas in reality, rising rice prices would cause simultaneous and offsetting increases in the incomes of high income families, and to a lesser extent medium income families, whose own-produced rice for consumption and sale would increase in value at the same rate as the price increase.

III. PRODUCTION SYSTEMS

Four topics will be discussed in this section of the report: technical and economic efficiency of production, patterns of technology adoption, constraints to the adoption of new technology, and the impact of new technology on income and employment. The first part presents findings based on production function analysis derived from farm level data gathered in Indonesia and the Philippines. The second portion of the section discusses the rate and timing of technical advancements in the adoption of rice technology across Asia, and in the individual study sites. In essence, the third part is a review of the literature pertaining to constraints to the adoption of new rice technology. This part of the report will also summarize the findings from a site in the middle hills district of Nepal, which was specifically chosen to detail how farmers view the appropriateness and prospects of new technology. The concluding portion of the section will discuss how technical change has influenced income and employment opportunities in the Philippine and Indian sites.

Technical and Economic Efficiency

Village A, Central Java, Indonesia

Using primary data collected in Village A, Hart has developed an econometric model to examine the technical and economic efficiency of input use. Since virtually no fertilizer or agricultural chemicals are used on the sample farms in Village A, the model concentrates on the inputs of labor and land. Several features of the model are unique. One of the most important aspects is an analysis of the separate contributions of male and female labor to the production of rice. Specification of the model is also unique in that it examines the issue of household attitudes towards subsistence by incorporating consideration of the proportion of household rice requirements in a variant of the basic constrained utility maximization model. Empirically, it integrates household time allocation, consumption, and production decisions in a peasant household. Leisure is viewed as a commodity, and a form of utility function is used to specify a complete system of demand equations for leisure and consumption goods. The basic constrained utility maximization model has been modified to take into account household attitudes towards risk, and the meeting of subsistence rice requirements. Readers interested in the complete model are referred to Hart (1978, Chapter VII). In the following pages the production aspect of the model will be sketched briefly, with emphasis on findings rather than the model's mathematical formulation.

Hart's model presumes that production behavior does not necessarily imply profit maximization. On the contrary, the adapted model predicts that the larger the amount of land controlled by a household, the more likely it is to underproduce relative to profit maximization. This would imply an inverse relationship between farm size and both labor input and yields per hectare.

Several interesting points can be observed in table III.1. This table shows yields obtained by sample farms in Village A. The farms are divided into five size categories. The data are for the wet season crop, and since land quality and irrigation practices are uniform across the different size classes and virtually no fertilizer is used, it may be assumed that yield differences are attributable to labor inputs. Yields range from a high of approximately 3.1 metric tons per hectare on the smallest farms, to about 2.0 metric tons per hectare on the largest. There is a striking difference in the use of labor on farms of various sizes. The largest farms (A) use an average of 824 hours of total labor per hectare, while the smallest farms (E), with .12 hectares of land, use 1,454 hours of labor per hectare. On the smaller farms household members supply almost 75 percent of the total labor. On farms in the largest size class, over 85 percent of total labor is hired. This represents a preference for leisure, as well as control over capital to hire labor. In the case of the smaller farm categories the cash restraint precludes hiring of labor, particularly male labor. Some female labor is hired at times of peak requirements when timeliness of operation is important. Higher yields are clearly associated with greater inputs of labor. More careful

TABLE III.1.--Labor Input[a] and Yields by Farm Size in Rice Production Preharvest Activities, Village A, Central Java, Indonesia (Wet Season in 1975-76)

		A >1.0	B .50-.99	C .30-.49	D .19-.29	E <.19
Average area (hectares)		3.147	0.676	0.377	0.271	0.118
Absolute labor input (hours)						
Female:	Family	40	45	54	87	65
	Hired	1209	211	109	72	27
	Total	1249	256	163	159	92
Male:	Family	1277	88	135	119	68
	Hired	1335	210	84	49	17
	Total	1462	298	219	168	85
Total absolute labor input		2711	554	382	327	177
Labor input per hectare (hours)						
Female:	Family	20	66	143	354	455
	Hired	360	306	306	266	233
	Total	380	372	449	620	688
Male	Family	70	133	383	456	619
	Hired	374	296	223	180	147
	Total	444	429	606	636	766
Total labor input per hectare		824	801	1055	1256	1454
Yield per hectare (tons of wet paddy)		1.965	2.318	2.220	2.546	3.123
No. of observations		6	13	13	11	17

Source: Hart (1978), p. 143.

[a]A female labor day (transplanting and weeding) is between four and five hours, whereas the average male labor day is seven hours. Labor data exclude supervisory work and travelling time. They also exclude activities such as protecting the crop from birds in the period before the harvest, and preparing food for laborers.

plant spacing, weeding, and water control contribute to the attainment of maximum yields per unit of land where holdings may be less than .2 hectares per household, and subsistence is an overriding concern. The question then arises, is the application of labor at these levels, particularly hired labor, economically rational?

Production function analysis was used to answer this question by determining if the marginal value product of labor and land differ across farm sizes in a systematic fashion. Production functions of three forms--transcendental, log-log inverse, and Cobb-Douglas--were fitted to the data. There was little difference in the results of the three functional forms, and it was decided to use the Cobb-Douglas function. This form was chosen because of the known uniformity of rice production technology across the five size categories. All farmers were growing local varieties of rice, and the use of fertilizer in even small amounts was rare.

The only variables in the model were size of land holdings and amount of male and female labor used in rice production. Careful specification of the labor variable is critical, and several considerations are relevant. First, all labor is assumed to be manual labor. Families hiring labor do perform some supervisory functions, but the bulk of labor hired is merely substituted for family manual labor. Labor may be hired if family labor is not available in sufficient quantity to carry out all productive tasks, or if the family members on farms with larger asset bases prefer leisure to agricultural work. Second, given the marked division of labor by sex it is extremely important to distinguish between male and female labor. Third, a question arises as to which pre-harvest activities should be included in the production function. Two models were estimated; the first included the labor of all pre-harvest activities, while the second model excluded the removal of seedlings from germination nurseries and transplanting.

The rationale for excluding these two activities in the second model is interesting. Detailed farm management data collected in Village A indicate that transplanting labor was virtually identical for farms of all size categories. Data on labor spent in seedling removal presented a more complex picture. Labor input per hectare for seedling removal varied only slightly among the second, third, and fourth size categories. However, the largest and smallest farms devoted more labor to seedling removal. In the case of the largest farms, additional labor was required to carry seedlings from the nursey to groups of transplanters working in different fields or in different locales on larger fields. The smallest land-holding farmers, particularly those who were sharecroppers, did not have their own nurseries. They germinated seeds in the nurseries of larger farmers, and therefore had to use additional labor to transport seedlings. It was felt that since seedling removal is a male activity, and transplanting is a female activity, including labor for these two activities would prove to be a confounding factor in interpreting the coefficients of the production function.

Other production activities which may be called "discretionary labor" included land preparation and water control, largely male activities, and weeding, which is typically performed by women. As it turned out, the judgment to exclude seedling removal and transplanting was a more accurate specification of the relationship between labor inputs and yields, therefore only the results of the second model are discussed here.

Estimates of this model are presented below. The figures in parentheses show the relationship of the coefficients relative to their standard errors.

$$\ln \text{yield} = \underset{}{-0.747} + \underset{(6.61)}{0.665} \ln \text{land} + \underset{(0.47)}{0.036} \ln \text{Female labor} + \underset{(1.92)}{0.212} \ln \text{male labor} \qquad \bar{R}^2 = 0.832$$

The marginal value products for land and labor computed for these estimates are presented in table III.2. The marginal value product of land was computed using the average price of paddy in the post-harvest period, 50,000 Rp/ton. It will be seen that the marginal value product for land increases consistently as farm sizes diminish. There are several reasons for this inverse relationship. The sum of the coefficients is less than one, which in a Cobb-Douglas function indicates decreasing returns to scale. In the study village, where drainage is more of a problem than irrigation, particularly in the wet season, it is possible that small plots have a more efficient drainage system. More important is the marked tendency for labor inputs, in terms of yields per hectare, to increase as farm size decreases.

Looking at the meaning of the labor results, apart from female labor in farm size group C, the marginal value product for both female and male labor decreases consistently with farm size. There appears to be a definite cut off between farms with more than a half hectare relative to those in smaller size groups. To interpret these results in terms of economic efficiency, the marginal value products of labor must be compared with wage

TABLE III.2.--Marginal Value Products of Land and Labor for Different Farm Size Groups, Village A, Central Java, Indonesia

Farm size groups (ha)	A >1.00	B .50-.99	C .30-.49	D .20-.29	E <.20
Discretionary Labor					
Predicted yield[a]	5.534	1.426	0.891	0.685	0.333
MVP land[b]	58513	70159	78615	83970	93943
MVP female labor	15.29	15.47	17.63	10.81	8.33
MVP male labor	59.24	58.38	48.45	47.73	47.12
Yields per Hectare					
Actual	1.965	2.318	2.220	2.546	3.123
Predicted (Model 2)	1.759	2.109	2.363	2.528	2.822

Source: Adapted from Hart (1978), p. 257.

[a]Yields in tons of wet paddy.

[b]Marginal value product (MVP) in Rupiah.

rates prevalent in the village. The hourly wage rate for female discretionary labor is 15 Rp/hr. This is almost precisely the marginal value product of female labor in the two largest size groups. The wage rate is considerably above the marginal value product of male labor on the larger farms. Average hourly wage rates for men were 43 Rp. On the small farms the marginal value product is fairly close to male wage rates.

In evaluating these results the following consideration should be borne in mind. The t ratios for female labor coefficients are very low, suggesting that the relative importance of female labor in rice production may not be estimated accurately. Given this caveat, the direction of change in the marginal value product across farm size groups is more important than their absolute values. The discrepancy between the marginal value product for female and male labor relative to their respective wage rates is illustrative of the differences between the structure of wage opportunities for males and females. The fact that the marginal value product is considerably lower than the wage rate reflects limitations in the availability of remunerative off-farm labor opportunities. This is the situation confronting women in the study village during the slack season. Female discretionary labor in the model is primarily weeding during the slack season when jobs for women within the village are very limited. The only alternative open to them during the wet season is very low wage rate labor on sugar cane estates outside the village. This option is exercised only by girls and women from landless households.

Women from households which own small quantities of land prefer to devote weeding labor to the family rice plot. In the case of men, non-farm labor is available in fishpond activity during the slack period in rice culture. It is also true that most hired male labor is concentrated in the peak period of rice production, hence the marginal value product of male labor on the smaller farms is fairly close to the wage rate. It is substantially below the marginal value product of male labor on large farms. This suggests that particularly in terms of male labor input, larger farms tend to operate at a point which is sub-optimal in terms of profit maximization.

These results are, of course, suggestive rather than definitive. They do, however, carry some interesting implications. From an empirical point of view, they cast doubt on the presumption that very small farms tend to be inefficient and suggest, in fact, the opposite. It is clear that the marginal value product of rice labor in this village is far from zero. In the case of activities performed by males, increasing labor input per hectare beyond a certain point does not decrease substantially the marginal value product of labor, whereas it does produce significantly higher yields.

Where families control very small parcels of land, yield considerations and a survival strategy override purely economic considerations. It would also appear that larger farmers prefer leisure, or at least the avoidance of manual labor by family members, to profit maximization. The model seemingly does provide a realistic description of the behavior of households with varying amounts of land.

Laguna and Central Luzon, Philippines

Ranade was fortunate in having a unique and extensive data base which allowed an appraisal of the impact of technical change in agricultural production over time. In 1966, IRRI collected farm level data from a sample of approximately 180 farms in Laguna province. In 1970, the survey was repeated, and usable data were obtained from 114 farms. Ranade extended the data base by surveying the same farms during the 1974 wet season. Similarly, data were collected by IRRI and Ranade for a sample of 70 farms in Central Luzon over the same time period.

In 1966, none of the farms in either sample were using modern rice varieties, and the use of fertilizer and agricultural chemicals was limited. At that time there was virtually no mechanical land preparation, and on the sample farms mechanical threshing was not widespread. By 1970, a significant proportion of the farmers were planting modern rice varieties released by IRRI. Fertilizer and insecticides were used by approximately 30 percent of the sample farmers. In 1974, all of the farmers were planting modern rice varieties, mechanization of both land preparation and threshing was widespread, and farmers were using a full range of fertilizer and agricultural chemicals. Ranade interpreted the data for 1966 as representing "traditional" agricultural practices, and the data for 1974 as representing "modern" agricultural practices.

In analyzing this data, Ranade was essentially looking at how technical change in rice production influences two factors: equity and efficiency. From the standpoint of equity, he wished to measure how the gains from technical change, as represented by increased rice output, were distributed between four socioeconomic groups: landlords, tenant farmers, landless laborers, and suppliers of purchased inputs. This process of estimating participant shares, and hence the distributional and equity aspects of technical change, was calculated through budget analysis. The findings of this analysis are presented on pages 51-57 of this report.

If all prices are determined competitively and factor markets are operating perfectly, the budgetary approach provides valid estimates of the marginal productivity and economic efficiency of factor use. On the other hand, if markets are not operating competitively and factors are not paid their marginal product because there is something awry in the factor markets, budgetary analysis is inappropriate in determining the marginal productivity of a given input. In addition, budgeting does not allow conclusions to be drawn concerning the substitutability of inputs.

Production function analysis was therefore used to address the efficiency issue, and to provide information as to the potential substitutability of various inputs in the production process. The budgetary and production function analyses may thus be viewed as complementary. Budgeting was used to determine the proportion of output received by various classes of participants before and after technical change. It is, however, desirable to know more about the impact of technical change. For example, what sorts of substitutability exist between factors of production? How would production be affected by a shortage of an input, or government intervention in the pricing or availability of an input? Production function analysis provides a more sophisticated approach in providing answers to questions of this type. When there is uncertainty concerning the competitiveness of input markets, production function analysis also provides valuable supplemental information to budgeting.

Ranade linked the budgeting and production function techniques by defining factor inputs in production functions so that they were comparable to participants in the budgets. These inputs were land (landlord's share), working capital (tenant's share), hired labor (landless laborer's share), and current inputs (input supplier's share). Coefficients of the production function analysis could then be compared with analogous elements of the budgeting analysis.

Variables used in estimating the production functions were measured as follows: Land was expressed in number of hectares planted to rice on each sample farm; chemical inputs were specified as the sum value of purchased fertilizer, insecticides, and herbicides. This sum was deflated by the farm level price of rice. Labor was specified as total mandays employed on a sample farm (note the exact specification of labor is somewhat different for Laguna and Central Luzon farms). Dummy variables were introduced to incorporate the influence of three types of irrigation. All farms in both of the sample sites grew only rice; hence, there were no complications as a result of changes in crop combinations.

Various functional forms were fitted to data from both the Laguna and Central Luzon sites for each of the three study years. Four functional forms were tested. The first was a Cobb-Douglas production function, and the other three functional forms were variations of the constant elasticity of substitution (CES) production function. The production elasticity of inputs for the two types of technology were estimated for each of the chosen functions at their mean levels.

The use of production function analysis allowed Ranade to compare imputed and actual factor payments and factor shares over time, and to thereby assess the economic efficiency of farmers' decisions. The imputed values are calculated using the assumptions that the production functions exhibited constant returns to scale and that profit maximization represented the efficiency norm. From these it follows that the percentage change in wage rates and laborer's share of output over time are weighted averages of the percentage changes in the land-labor and capital-labor ratios, multiplied by the degree of substitutability of land and capital for labor. The designated weights are equal to the factor shares of land and capital respectively.

Examination of the resulting algebraic expressions indicated that the appropriate measure of factor substitutability is that developed by Hicks (Sato and Koizumi, 1973). Economic literature offered several different expressions for, and interpretations of, the concept of pairwise input substitution. There are other measures of factor substitutability, but Ranade found that they either led to inconclusive results or were inappropriate when there were more than two variable factors of production and all input levels changed simultaneously. In addition, the Hicks coefficient was flexible enough to be appropriate for a variety of different functional forms. Therefore, the form of the production function specified was not subject to unnecessary constraints.

The original coefficients of the production functions were also helpful in the analysis. Partial elasticities of substitution were useful in ascertaining differences in the derived demand for inputs, while the direct elasticity of substitution allowed an assessment of pure factor substitutability. However, the Hicks coefficients were superior in measuring changes in factor shares between the two technologies over time.

The estimation of production elasticities from the sample data proceeded as follows. First, Cobb-Douglas production functions were fitted to the data from both the Laguna and Central Luzon sites for each of the three sample years. A statistical test was performed to see if the assumption of technological change was supported by the data. The test revealed a significant structural change. Then three production functions of the constant elasticity of substitution form were estimated. One function was chosen as the best representative of traditional technology, and another as representative of modern technology. Traditional production elasticities and Hicks coefficients were then derived from the estimated parameters of the chosen functional form. Production elasticities were compared with the relative shares calculated from the budgetary analysis. Estimates were also made which allowed determination of the factor-saving bias of moving from traditional to modern technology. Implications were drawn concerning the factor-saving bias of changes in the relative shares accruing to various factors resulting from technical change and input substitutability under traditional and modern agriculture.

Laguna. Analysis of factor income distribution calculated from the budgetary analysis indicated that while all participants in rice production benefited from technological change, the relative share of current input suppliers increased, while those of landlords and tenants decreased. Since land area was fixed, reduced landlord shares implied that land rent did not increase as rapidly as yields during the study period. While the relative share of total labor declined, decomposition of labor into hired and family components indicated that the share of output going to hired labor did not decrease. Real wages and total employment increased from traditional to modern technology. The relative decline in the share received by total labor, therefore, was accounted for by the income and employment of tenant labor.

The Cobb-Douglas functions proved to be the best representation of traditional technology, while the CES function containing interaction terms between chemical inputs and labor was found to be the best speficication for modern technology. The CES specification implies that production elasticities of labor and chemicals vary with the ratio of labor to chemical usage.

The estimate of the production elasticity of labor was found to differ significantly from the observed relative share in the budget analysis. In an attempt to better understand this discrepancy, labor was segmented into labor for land preparation and other labor. Re-estimation of the functions indicated that the elasticity for land preparation labor was close to its relative share, while the elasticity for other labor was not significantly different from zero. Since the variability of other labor in the sample was observed to be small, Ranade concluded that traditional producers operated at close to the maximum level of production with respect to labor, and thus the marginal product of other labor was close to zero. Further analysis revealed that for traditional technology, other labor was paid more than its marginal product. This, however, was not found to be the case for modern technology, nor for any of the other inputs with either technology. Thus there was no evidence of any significant inefficiency in resource use in Laguna.

Production function analysis indicated that the capacity to substitute chemicals for land in rice production, while holding output constant, is twice as large under modern as traditional technology. Modern technology (high yielding rice), therefore, is found to offer considerably more latitude for maintaining production of rice and freeing land for other uses. Modern technology, in general, offers greater opportunities for the substitution of chemicals for land or labor than does traditional technology.

Production elasticities were compared over the three time periods. Results indicate that rice yields in traditional technology were mainly dependent upon land, while in modern technology incremental returns from adding other inputs, notably chemicals, were substantial. Land, therefore, has a lower production elasticity in modern technology. This is consistent with the finding that other inputs take on increased importance in the production process with technological change. This seemed more evident in the 1970-1974 period than in 1966-1970. The inference is that the combination of chemicals and, to some degree, mechanization are complementary to high yielding varieties.

Further analysis of production elasticities indicates that laborers were not paid less than their marginal product in either technology.

This suggests that technological change did not interfere with the competitive operation of labor markets. Labor productivity was found to be higher under the modern technology.

Results of the study indicate that the high yielding rice varieties exhibited both land-saving and labor-saving aspects, but that the land-saving bias outweighs the labor-saving bias. The implication is that the introduction of high yielding rice varieties will tend to offer greater potential for reducing land requirements needed to produce a given level of output, than for reducing the amount of labor required.

Central Luzon. As in the case of Laguna, the budgetary analysis indicated that all participants in the production process benefited in absolute terms from the adoption of modern rice technology. But not all participants shared equally in the increased rice output. In Central Luzon, the relative shares of landlords decreased as in Laguna; however, in contrast to the Laguna findings, the relative share of hired laborers decreased with the adoption of modern technology in Central Luzon. This is attributable to the fact that there was no appreciable increase in the real wage rate within Central Luzon, while the wage rate in Laguna did increase modestly over the eight year period.

The production functions estimated for Central Luzon were essentially the same as those for Laguna. It was found, however, that the introduction of slope shifters for both mechanization and irrigation provided a better fit for the Central Luzon data. The labor input specification was also different in Central Luzon. The sum of equivalent horsepower days of draft animals and tractors was used to represent land preparation labor. Furthermore, data limitations allowed only the use of pre-harvest labor. Ranade did not consider this a serious problem, since he reasoned that the level of harvest labor did not appreciably affect yield or total rice output.

Estimated production elasticities for land preparation labor and other pre-harvest labor were found to be close to the relative shares calculated from the budgetary analysis. This was true for both traditional and modern technology, although there was some evidence that labor used in land preparation in modern technology was paid more than its marginal product. Thus again, there was no evidence of significant inefficiency in the allocation of resources.

The decline in the production elasticity of land preparation labor observed in the modern technology is apparently greater in Central Luzon than in Laguna. This is assumed to be attributatle to a greater increase in the mechanization of plowing and other land preparation activities on Central Luzon farms.

The introduction of semi-dwarf rice varieties in 1970 appears to be the factor contributing to an increase in the production elasticities of chemicals and labor, other than that used in land preparation. As in Laguna, it was found that when an increased quantity of one input was used, it resulted in a negative impact on the price of other inputs. In the case of modern technology, the intensity of these effects was greater in Central Luzon than in Laguna. This was particularly marked in the relationship between chemical and labor use. The implication is that in Central Luzon the relative shares flowing to an input are quite sensitive to the ratio of factor usage.

In contrast to the Laguna findings, all factors of production in Central Luzon were found to be complementary on modern farms. Factor proportions were found to change in the same direction as the ratio of factor prices. If the production of a given level of output is held constant, the substitutability of land for pre-harvest labor is considerably higher in modern than traditional technology. Interestingly, land and chemicals were found to have less substitutability in modern than in traditional technology. In Central Luzon modern technology was both land and pre-harvest labor-saving. This was also the case in Laguna; however, in Central Luzon, the factor-saving bias was larger for pre-harvest labor than for land.

It is important to make several observations relative to the use of production function analysis in the Philippines and the validity of findings from this approach. The methodology was to look at the full distributional effects of technology and not merely at biological or socio-economic effects. The results seem to contradict the findings of other studies, which indicate that landlords and owners of other inputs receive a disproportionate share of all gains attributable to modernizing agriculture. This research suggests that further analysis of the distribution question should be considered. The methodology of combining budgetary analysis with production functions provides at least a starting point for an interesting verification of findings. In general, the production function analysis supported the budgetary findings; however, the marginal increase in information useful to policy makers was not great. Ranade's contribution is that he pioneered the use of an empirically powerful technique of analysis. If this provides a building block for other researchers, then the exercise will have served a useful purpose.

Patterns of Technology Adoption

Given that modern varieties of rice were first introduced in Asia in 1965/6, it is revealing to consider the time path of their adoption against the adoption paths for other modern technologies. Such a comparison is possible using the IRRI data presented in table III.3. It is especially interesting to note that in some Asian countries a significant number of the farmers sampled by IRRI in 1971/2 had adopted other modern technologies prior to the introduction of modern rice varieties. For example, 75 percent of the sample Indonesian farmers, 62 percent of those in Pakistan, and a respectable number of those in the other countries, had employed inorganic fertilizer prior to 1966, and on a significant number of farms its use could be traced back to before 1960. Tractors were relatively common in Pakistan and the Philippines before 1966; mechanical threshers and herbicides were likewise employed on more than 30 percent of Philippine farms; and insecticides were widely used prior to 1966 in all the surveyed areas except Malaysia and Pakistan. Of course, it would be misleading to suggest that these levels of adoption had occurred during a period in which there had been no improvement in the genetic quality of rice varieties--there certainly were national programs of rice trials. These, however, pre-date the major international program of genetic research associated with IRRI which led to the commercial release of the so-called modern varieties of rice (MV) in 1965/6. It also indicates that the reasons for adopting these other technologies

TABLE III.3--Cumulative Proportion (%) of Farmers Who had Used Modern Technology in 31 Villages in Selected Areas of Asia, by Technology Type, by Country

	1900–1960	1961–1966	1967	1968	1969	1970	1971	1972	Percentage Using in 1972
Modern Varieties of Rice[f]									
India	0	0[d]	27	43	77	93	96	96	()[c]
Indonesia	0	0	28	64	83	88	90	90	()[c]
Malaysia[a]	0	0[e]	—	—	--	--	100	100	()[c]
Pakistan	0	0	0	11	21	38	100	100	()[c]
Philippines	0	0	36	71	91	99	100	100	()[c]
Thailand	0	0	0	0	0	41	92	82	()[c]
Fertilizer[a]									
India	6	41	60	70	91	97	98	100	99 (100)[b]
Indonesia	32	75	81	94	99	99	99	99	99 (96)
Pakistan	27	62	65	72	79	80	81	81	76 ()[c]
Philippines	15	33	51	67	77	80	83	84	72 (76)
Thailand	2	20	27	38	50	61	76	82	69 (82)
Tractors									
India	0	9	11	13	20	22	27	27	26
Indonesia	0	0	1	3	5	14	15	15	2
Malaysia[a]	--	--	--	--	--	—	--	96	96
Pakistan	3	46	57	67	72	73	73	73	73
Philippines	10	24	37	46	57	61	61	61	58
Thailand	0	5	6	9	15	22	33	33	25
Mechanical Threshers[a]									
India	0	7	8	9	9	9	9	9	9
Indonesia	0	0	0	0	0	0	0	0	0
Pakistan	0	0	0	0	0	0	0	0	0
Philippines	19	27	38	50	62	65	65	66	63
Thailand	1	6	11	27	38	45	55	55	44
Insecticide									
India	3	31	48	63	80	89	91	91	88
Indonesia	31	68	74	92	93	96	96	96	92
Malaysia[a]	--	--	--	--	--	—	—	45	45
Pakistan	4	9	9	25	42	55	58	58	58
Philippines	16	43	59	75	89	95	97	97	97
Thailand	5	32	39	42	50	56	76	76	71
Herbicide									
India	—	1	1	2	2	2	2	2	0
Indonesia	--	0	0	0	0	0	0	0	0
Malaysia[a]	--	—	--	--	--	—	—	8	6
Pakistan	--	0	0	0	0	0	0	0	0
Philippines	—	32	45	51	67	71	72	76	65
Thailand	--	4	6	6	7	10	10	10	8

Source: IRRI (1978a), pp. 16, 99, 100.

Notes: [a]Data missing for Malaysia for all or part of the period.
[b]The figures in parentheses are for the dry season, the others for the wet season.
[c]Not available.
[d]Modern rice varieties were introduced in India in 1965/6.
[e]Modern rice varieties were introduced in Malaysia in 1965.
[f]The data on adoption of modern rice varieties is for 32 villages. Data for Zarain in India was omitted in calculating the other statistics.

are not to be found solely in the technical and economic conditions brought about by the introduction of MV. Of the technologies considered in table III.3, only fertilizer (and to a lesser extent, insecticide) appears to have a general complementarity with MV. This is indicated by the fact that in all six countries by 1972, over 80 percent of surveyed farmers had used both MV and fertilizer, while for each of the other technologies adoption had fallen well below this level in one or more countries, although this was less marked in the case of insecticide.

That fertilizer and MV should emerge as being complementary is hardly surprising in view of the fact that most MV have been selected to be fertilizer-responsive in conditions of adequate irrigation and water supply. Likewise, the relationship between the use of MV and technologies other than fertilizer are consistent with their properties as presented in the classification of technologies on pages 13-15. Tractors, mechanical threshers, and herbicides are all considered to be labor-substituting and would therefore not be expected to be adopted extensively where labor is abundant at periods of peak labor demand. Thus, for example, the adoption of all three of these technologies is much lower in Indonesia than it is in the Philippine sample, where the farms are on average from three to six times as large. However, as the framework set out in section I of this report (pages 16-36) indicates, a complex set of variables is required to explain the different "technology packages" adopted in each of the survey countries. For example, in Central Luzon the high adoption of mechanical threshers up to 1972 reflects, in part, a method by which large landowners reduced the number of harvest laborers and gained control over the share of the harvest distributed. As can be seen from table III.4, the use of such machines declined between 1970 and 1976 as a consequence of the fact that the Philippine land reform eliminated the largest holdings, which had used threshers as a device to control the distribution of output between landlord, tenant, and landless laborers. The more widespread use of contract harvesting also contributed to the decline in the use of mechanical threshers.

It is very interesting to observe the influence of farm size upon the technologies adopted. As can be seen from table III.5, there is comparatively little difference between the three farm size categories in their rate of adoption of MV, fertilizers, and insecticides. In fact, the largest farms have a marginally lower rate of adoption of these technologies, but show a markedly higher rate of adoption of mechanical technology (tractors/mechanical threshers). The smallest size class has the lowest rate of adoption of mechanical and herbicide technology. This tends to confirm that these particular new technologies are not indispensable complements to the other new technologies, but are largely substitutes for traditional factors. It will be recalled that data presented in table III.3 showed that in Village A, where only traditional inputs were employed, smaller farms obtained considerably higher yields per hectare through the use of substantially larger quantities of labor per unit of land. Higher yields then, are not only attributable to the adoption of modern technology.

In one important respect the data presented in tables III. 3 and III.5 are potentially misleading. For example, although in Pakistan 100

TABLE III.4--Percent of Sample Farms Using New Technology, Central Luzon,[a] Philippines

	Tractors for Land Preparation	Mechanical Thresher	Rotary Weeder	Herbicides	Modern Rice Varieties	Irrigation
1966	17	66	9	17	0	60
1970	45	59	17	40	67	61
1974	56	42	18	58	82	61

Source: Ranade (1977), pp. 216, 221, 228, 245.

[a]Based on a sample of 114 farms for the wet season only.

TABLE III.5--Cumulative Rate of Adoption of Some Improved Rice Culture Practices by Farmers in Selected Areas in Asia, 1971/72

Practice, farm size	Cumulative rate (%) of adoption 1900-1960	1961-1966	1967	1968	1969	1970	1971	1972
				MV				
1 ha or less	0	13	35	69	85	89	93	93
1.1 to 3.0	0	9	27	56	89	98	99	99
over 3 ha	0	7	19	34	49	68	92	92
				Fertilizer				
1 ha or less	23	55	73	92	96	97	98	98
1.1 to 3.0	10	34	48	64	78	83	86	88
over 3 ha	14	50	61	73	81	86	90	91
				Insecticide				
1 ha or less	23	49	64	84	89	92	93	93
1.1 to 3.0	12	39	53	67	87	94	95	95
over 3 ha	6	32	45	52	62	70	83	83
				Herbicide				
1 ha or less	0	0	0	0	0	0	0	0
1.1 to 3.0	6	13	16	21	29	31	32	32
over 3 ha	3	27	39	48	56	63	71	71
				Tractor				
1 ha or less	0	18	19	20	21	25	25	25
1.1 to 3.0	6	13	16	21	29	31	32	32
over 3 ha	3	27	39	48	56	63	71	71
				Mechanical thresher				
1 ha or less	0	0	1	1	1	1	1	1
1.1 to 3.0	8	12	15	22	31	32	33	33
over 3 ha	9	21	30	35	39	41	44	44

Source: IRRI (1978a), p. 91.

percent of the sampled farmers had tried MV by 1972, it is not the case that the whole rice area in the sample villages was planted to MV, and even less true that all rice grown in Pakistan was MV. This is clearly demonstrated by reference to table I.8, which shows that in 1972/3, only 43.7 percent of the rice area in Pakistan was in MV, and moreover that this had declined by 1976/7, to 39.8 percent. It is not only in Pakistan that there have been some minor reverses in the growth of the area sown to MV. Table I.8 also shows a sharp decline in the area of MV in Indonesia in 1975/6, the year of Hart's survey, and a minor decline in Nepal after 1974/5. Similar qualifications attach to adoption of the other technologies, and it cannot be inferred from the fact that a high proportion of sampled farmers used a particular technology in 1972 that they did so on all of their land or at a high level of application.

Historically, rice production in Asia has been increased by applying labor and traditional cultural practices to an ever-increasing area. As long as sufficient new land was available, this technique provided the means for supplying a population which grew at modest rates. There continued to be an adequate supply of new rice land until a decade or more after World War II. With the spread of medical technology, which included inoculation against communicable diseases, control of malaria through mosquito eradication programs, improved sanitation, and expanded food aid, death rates fell and the Asian population began to grow rapidly. In the 1960's the land constraint became acute. As discussed above, there was a shift from dependence on area expansion to increasing per hectare yields to expand the food supply.

Crop area continued to expand with improved irrigation and enlargement of the area double cropped, but the physical area in rice in South and South East Asia has expanded very little over the past decade. For those countries whose production grew by more than 2 percent a year, only in Thailand did area expansion play an important role in the growth of rice output. Table III.6 provides an excellent summarization of the factors which have contributed to increased rice production from 1965 to 1973. Aggregate growth rates in production have been divided into three contributory components: irrigation, fertilizer, and residual factor. This provides some additional perspective concerning how technology adoption influences production growth.

In Hart's study in Central Java, production systems were not the focus of attention, and therefore comparatively little information is available on the topic of technology adoption. It is, however, reasonable to assume that in line with the labor data presented in tables III.1 and III.3, no farmers in the study village employed mechanical technology. Surprisingly, Hart (1978) also reports that fertilizer use was very rare; this clearly is not typical of Indonesian agriculture and may be a result of the temporary abandonment of MV in 1975/6. It will be recalled that MV had been adopted in Village A only to be abandoned as a result of severe infestation of brown leaf hoppers. Since 1975/6, the use of MV has been resumed and MV are currently being used by 75 percent of farmers on at least a portion of their land.

Ranade's Philippine survey provided a fuller picture of technological change for the Central Luzon sample (table III.4) than for Laguna

TABLE III.6.--Estimated Proportion of Growth in Rice Output Attributed to Components of Area and Yield for Selected Asian Countries, Mid-1960's to Early 1970's

Country	Period	Annual rate of production growth (%)	Percentage points (%) attributed to			
			Area		Yield	
			Irrigated	Unirrigated	Fertilizer[a]	Residual[b]
Pakistan	1965-73	7.9	1.4	0	1.7	4.8
Malaysia	1965-73	5.7	3.7	0.1	1.4	0.5
Sri Lanka	1965-72	5.6	0.5	0.1	3.5	1.5
Indonesia	1965-72	4.8	2.2	-0.3	1.1	1.8
Philippines	1965-73	3.4	1.2	-0.3	1.5	1.0
India	1965-70	3.2	0.6	0.2	1.5	0.9
Thailand	1965-72	2.1	0.2	1.7	0.3	-0.1

Source: Barker (1978), table 1.

[a]Calculated on the basis of 10 kg yield for every 1 kg of fertilizer

[b]Includes the contribution to yield of improved quality of land due to higher proportion of irrigated area.

(table III.7). Comparison with data in table III.3 shows that changes in Central Luzon compare closely with the data for the larger survey: tractor using farms have increased from 17 percent in 1966, to 56 percent in 1976, while use of mechanical threshers has declined from 66 to 42 percent over the same period. Table III.4 indicates that herbicide use is somewhat lower than the average for the 13 IRRI survey villages in the Philippines. This can be attributed to the somewhat lower rate of adoption of modern varieties, which in turn can be explained by the relatively low irrigation rate.

For the Laguna survey, data studied by Ranade (table III.7) appear to indicate that tractor use for land preparation was at a somewhat higher level than in Central Luzon. Assuming farmers using tractors for plowing also use them for harrowing, a total of 36 percent of Laguna farmers used tractors for wet season land preparation in 1965/6, and 71 percent in 1970/1; the comparable figures for Central Luzon are 17 and 45 percent (table III.4). This comparison matches the more comprehensive data (in terms of technology coverage) which Cordova and Barker (1977) computed for subsamples of the data used by Ranade (table III.8). The Cordova and Barker data also indicate that no mechanical threshers were employed in Laguna, but that herbicide use was higher than in Central Luzon and has remained above the 85 percent level since 1966/7.

Regarding technology adoption in Chittoor District, India, the available data relate only to the state of adoption of mechanical technology in 1976; this has been presented in tables I.23 and I.24, and discussed in section I, pp. 75-81. It will be recalled that the Chittoor District

TABLE III.7--Percent of Sample Farms[b] Using New Technology, Laguna,[c] Philippines

	Tractors for Plowing[a]		Tractors for Harrowing[a]		Modern Rice Varieties
	Whole Acreage	Part Acreage	Whole Acreage	Part Acreage	
1965/6	2 (4)	4 (1)	10 (9)	26 (18)	0
1970/1	8 (3)	3 (0)	33 (30)	38 (35)	100

Source: Ranade (1977), pp. 109.

[a]Data in parentheses are for the dry season, the others for the wet season.

[b]The sample consisted of 114 farms in the wet seasons of 1965/6 and 1970/1 but of 81 in the dry seasons of these years.

[c]Mechanical threshers were not used in Laguna.

TABLE III.8--Percent of Farms by Technology Adopted, 62 Laguna Farms and 63 Central Luzon-Laguna farms, Philippines, 1966-75, Wet and Dry Seasons

Technology	Laguna 1966/67	Laguna 1970/71	Laguna 1974 Dry 1975 Wet	Central Luzon-Laguna 1966/67	Central Luzon-Laguna 1970/71	Central Luzon-Laguna 1974 1975
			Technology - wet season (%)			
MV (100%)	0	76	94	0	57	64
MV (partial)	0	19	5	0	10	19
Tractors	26	71	90	17	43	57
Herbicides	86	97	92	19	41	61
Threshers	0	0	0	72	69	42
			Technology - dry season (%)			
Dry season farms (no.)	45	54	51	15	14	26
MV (100%)	0	76	94	7	93	na
MV (partial)	0	24	4	13	0	na
Tractors	24	65	na	62	80	81
Herbicides	87	97	93	62	50	na
Threshers	0	0	0	46	50	19

Source: Cordova and Barker (1977).

sample was selected because of its especially high level of tractor ownership and use. This is also associated with a higher than average ownership of other forms of mechanical technology reflecting (1) the large range of operations for which tractors are used in this area, (2) the complex and diverse cropping patterns, and (3) the above average wealth of the surveyed farms.

Constraints to the Adoption of Technology

The Cornell research on the Indonesian, Philippine, and Indian sites did not focus specifically on constraints to the adoption of modern rice technology. However, field work was conducted in Nepal to specifically address this issue, since it was assumed that among farmers within the Nepalese middle hills there was wide variability in both cropping patterns and the use of modern inputs. With the exception of findings from Nepal, this portion of the report will synthesize the conclusions of several research efforts directed toward the measurement and reasons for the wide variety of constraints.

At a very general level it is recognized that because most research to date has been directed to irrigated rice, the modern seed-fertilizer technology is best adapted to irrigable areas and is less applicable, and therefore, less likely to spread to rainfed, upland, and deepwater rice growing areas. Thus there are clear ecological constraints to the spread of technology to many rice-growing districts in Asia. As table III.9 indicates, a substantial proportion of the area devoted to rice production in Asia is not irrigated. This has been clearly recognized in a recent paper by Barker and Herdt, which concludes that in the future, returns to research to improve rainfed rice production may exceed potential returns from further research into irrigated rice production.

Estimates by the Long Range Planning committee of the International Rice Research Institute indicate that over the next 10 to 15 years,

TABLE III.9.--Estimates of the Proportion of Rice Area in Five Major Environmental Categories, 11 Asian Countries, 1970-75

Country	Total rice area ('000 ha)[a]	Proportion of area				
		Irrigated	Rainfed	Upland	Deep-water	Second crop
		(%)				
India	37,755	40	50	5	5	5
Bangladesh	9,766	16	39	19	26	10
Indonesia	8,482	47	31	17	5	19
Thailand	7,037	11	80	2	7	2
Burma	4,985	17	81	1	1	1
Philippines	3,488	41	48	11	0	14
Vietnam[b]	2,713	15	60	5	20	5
Pakistan	1,518	100	0	0	0	0
Nepal	1,200	16	76	9	0	0
Malaysia (W)	771	77	20	3	0	50
Sri Lanka	604	61	37	2	0	25

Source: Herdt (1976), table 1.

[a]1970-74 average area, FAO data.

[b]Former South Vietnam.

approximately half of the total possible rice production gains attributable to research will be realized on irrigated areas, while another one-third of the potential increase will come from rainfed lowland areas. The research required for these separate areas is distinctly different. Modern varieties have been adopted in most of the irrigated areas and use of inputs, particularly fertilizer, has increased markedly over the past decade. Insect and disease problems are becoming acute in areas of intensive irrigated rice production. Here the challenge will be the development of new resistant varieties.

In the areas of Asia where rice is produced on rainfed lowlands, poor water control has prevented the adoption of modern varieties, and only modest yield increases have been achieved in these areas. There are two basic strategies for increasing production in rainfed areas. First, alter the environment to fit available technology. This would include irrigation, and in some cases, drainage. Second, technology can be developed to fit the environment. This would involve the development of drought and flood resistant varieties. An increase in the acreage of irrigated rice will be costly; it then appears that there is a particularly high payoff from research which will increase yields in the rainfed areas. The main obstacle confronting researchers is the heterogeneity of the environment. Some areas need rice varieties with short growing season requirements or drought tolerance, while other areas require varieties able to withstand flooding or stagnant water conditions.

Although it is comparatively easy to qualitatively identify constraints to the adoption of technology, their significance can only be assessed fully by some form of quantitative analysis. Thus the impact of a constraint should ideally be measured as the amount by which it reduces the use of particular inputs, and in turn, the impact on output. However, underlying any such measure is the normative concept of some level of input use and output, which should or could be achieved. Clearly, this is difficult to define, and there may well be a danger that these "target" levels of technology will be set too high, with the consequence that expectations about what can and should be achieved will also be too high. Certainly this is one implication of a very interesting research project carried out by IRRI (IRRI, 1977; Barker, 1978). This project starts with the premise that constraints to obtaining higher yields can be classified into two groups: Those which affect the potential yield within the environment confronted by the farmer; and those which influence the farmer's ability to attain the yield potential.

> The first category of constraints is related directly to the development of new technology and hence the organization of research. The second is concerned on one hand with the realization of production potential given the existing technology and physical environment, and on the other with the degree of equity among farmers and landless workers in access to resources and inputs. These include such issues as diffusion of knowledge among farmers, input and credit availability and land ownership patterns. (Barker, 1978, p. 6.)

The research organized by IRRI involved an appraisal in farmers' fields of a number of management (input) levels ranging from those actually utilized by farmers (the lowest level of technological adoption) to the high input levels recommended by experiment stations. Two yield gaps were identified. Yield gap I is defined as the difference between yields on the nearest experiment station and yields achieved on farmers' fields where the highest level of technology was adopted. This gap is attributable to the first set of constraints noted above, and was interpreted as indicating the extent to which technology was not transferable between experiment station and farm, and to environmental differences between the two. While this gap may be reduced by investment in such improvements as water control, it cannot be interpreted as being due to any failure on the part of farmers to exploit the resources at their command. Yield gap II, which measures the difference between the yield achieved by farmers using the high input package and those using traditional or typical input levels, is the more interesting in that it indicates the gap between what was and what could be achieved given the existing water control system. It indicates the potential return to policies designed to encourage and assist farmers to change their input types and levels.

Management packages intermediate between those used by farmers and high input levels were also tested factorially. This permitted identification of the inputs which would contribute most to closing yield gap II. It also enabled estimation of output response to various inputs, which in turn enabled evaluation of the economically optimum package of inputs, and the extent (if any) to which this differed from the high input package.

It should, however, be noted that the high input package relating to the potential yield figures in tables III.10 and III.11 were not the highest input packages capable of producing marginal positive increases in rice yields. They were the highest input levels considered managerially feasible for practicing farmers. Thus the term "potential" has been used in a rather special way in this study, and it is not the same as the maxi-

TABLE III.10.--Measured Potential Rice Yield[a], Actual Yield, Yield Gap[b] and Contribution of Three Types of Inputs in Experiments on Farmers' Fields, Wet Seasons, Selected Asian Sites, 1974-75

Location	Year	Trials (no.)	Yield (t/ha)			Contribution (t/ha) of			
			Farmers'	Potential	Gap	Fertilizer	Weed control	Insect control	Residual
Philippines									
Nueva Ecija	1974	10	1.9	2.3	0.4	-0.1	0.2	0.4	-0.1
Indonesia									
Subang	1975	4	2.2	2.4	0.2	0.1	-0.1	1.3	-0.1
Bangladesh									
Joydebpur	1976[c]	9	2.7	2.8	0.1	0.1	-0.1	0.1	0
Sri Lanka									
Giritale	1975/76	4	2.9	4.0	1.1	0.2	0.2	0.8	-0.1
Philippines									
Nueva Ecija	1975	11	3.2	3.9	0.7	0.3	0.1	0.2	0.1
Laguna	1974	10	3.6	5.6	2.0	1.1	0.3	0.8	-0.2
Laguna	1975	20	3.6	5.3	1.7	0.7	0.3	0.7	9
Camarines Sur	1975	6	3.6	4.6	1.0	0.4	0.1	0.6	-0.1
Thailand									
Supan Buri	1974	3	3.7	5.1	1.4	0.7	0.3	0.3	0.1
Supan Buri	1975	7	3.9	4.6	0.7	0.5	0.1	0.2	-0.1
Indonesia									
Yogyakarta	1974/75	3	4.2	4.7	0.5	0.7	-0.1	-0.1	0
Taiwan									
Taichung	1975	3	5.6	6.6	1.0	0.5	0.2	0.1	0.2

Source: Herdt (1976), table 4.

[a]The high input packages which produced the potential yields were not in all cases the highest input packages which could have been applied with positive marginal yield. Thus potential in this case is not strictly equivalent to maximum attainable yield.

[b]This refers to yield gap II.

[c]Aus season.

TABLE III.11.--Measured Potential Rice Yield[a], Actual Yield, Yield Gap[b] and Contribution of Three Types of Inputs in Experiments on Farmers' Fields, Dry Season, Selected Asian Sites, 1975-76

Location	Year	Trials (no.)	Yield (t/ha)			Contribution (t/ha) of			
			Farmers'	Potential	Gap	Fertilizer	Weed control	Insect control	Residual
Indonesia									
Yogyakarta	1975	2	2.6	3.9	1.3	1.0	0.4	-0.3	-0.4
Subang	1976	3	3.1	3.5	0.4	0.3	0.1	0	0
Bangladesh									
Joydebpur	1975/76[c]	6	3.5	5.2	1.7	1.3	0.4	na	0
Philippines									
Camarines Sur	1976	8	3.3	4.8	1.5	1.3	0.1	0.2	-0.1
Camarines Sur	1975	3	3.9	5.6	1.7	1.1	0.1	0.4	0.1
Thailand									
Supan Buri	1975	7	4.1	6.3	2.2	1.5	0.5	0.3	-0.1
Philippines									
Nueva Ecija	1976	8	4.2	6.2	2.0	1.3	0.3	0.6	-0.2
Nueva Ecija	1975	3	4.3	5.2	0.9	0.2	0.5	0.2	0
Laguna	1976	12	4.4	6.1	1.7	1.0	0.2	0.6	-0.1
Laguna	1975	9	5.6	7.4	1.8	1.3	0.2	1.0	0.1
Taiwan									
Taichung	1976	3	6.2	7.0	0.8	0.5	0.2	0.1	0

Source: Herdt (1976), table 5.

[a]The high input packages which produced the potential yields were not in all cases the highest input packages which could have been applied with positive marginal yield. Thus potential in this case is not strictly equivalent to maximum attainable yield.

[b]This refers to yield gap II.

[c]Boro Season.

mum attainable yield in farmers' fields. It has been used here to denote the potential which could be attained by the farmer in his own fields, rather than the maximum attainable by researchers in farmers' fields. In other words, it relates solely to yield gap II.

The estimates which were obtained for yield gap II in the wet and dry seasons are indicated in tables III.10 and III.11, respectively. The results indicate that in the wet season this gap is relatively modest, and that it averaged only 0.9 metric tons per hectare over the various study sites, with a range from 0.1 to 2.0 metric tons. In the dry season the gap was found to be larger, with an average of 1.5 metric tons per hectare and a range of 0.4 to 2.2 metric tons. Significantly, these potentials for increased yields are less dramatic than experiment station results might suggest, thus emphasizing that there is a risk of setting expectations too high. Nevertheless, the potential to increase yields does appear to exist in the irrigated areas studied and could be realized primarily by increased application of fertilizer, and also by improved insect and weed control.

Although care must be taken not to confuse the maximum yield in table III.12 with potential yield in the preceeding two tables, the table does indicate that in the wet season it would have been uneconomic at nearly all the sites for farmers to have attempted to achieve potential yields by applying the high input package. In fact, only at Camarines Sur was the potential wet season yield economically optimal. At most of the other sites the economic optimum level of input use was little or no higher than that actually used by farmers. Thus the economic potential

TABLE III.12.--Increased Profit and Rice Yield of Alternative Input Management Packages Compared to Farmers' Practices, from Experiments on Farmers' Fields, Selected Asian Sites, 1974-76

Location	Year	Trials (no.)	Increased net return per hectare over farmers practices					Increased yield (t/ha)	
			Units	M2[a]	M3	M4	M5	at max. net return[b]	at max. yield
				Wet seasons					
Philippines									
Nueva Ecija	1974	10	Peso	31	-358	-902	-2053	0.2	0.7
Nueva Ecija	1975	11	Peso	205	146	-178	-256	0.2	1.2
Laguna	1975	5	Peso	-841	-1751	-1262	-1056	0	1.3
Camarines Sur	1975	6	Peso	381	658	-158	-846	1.1	1.1
Thailand									
Supan Buri	1974	3	Bhat	336	836	-540	-2281	0.9	1.4
Supan Buri	1975	6	Bhat	-422	-1023	-3034	-4316	0	0.4
Indonesia									
Yogyakarta	1974	3	Rupiah	-14000	11330	-1660	10660	0.5	1.0
Sri Lanka									
Giritale	1975	4	Rupees	1528	1399	829	855	0.5	1.2
				Dry seasons					
Philippines									
Nueva Ecija	1975	3	Peso	-486	-522	280	357	2.1	2.1
Nueva Ecija	1976	9	Peso	a	820	1748	1864	2.3	2.3
Laguna	1975	9	Peso	-690	-666	-65	-768	0	1.5
Laguna	1976	7	Peso	a	1045	1296	2153	2.1	2.1
Camarines Sur	1975	3	Peso	-536	177	307	-181	1.5	2.0
Camarines Sur	1976	5	Peso	a	283	221	561	1.8	1.8
Thailand									
Supan Buri	1975	7	Bhat	365	488	-1167	-1455	1.1	2.2
Indonesia									
Yogyakarta	1975	2	Rupiah	22000	51000	80000	157000	2.7	2.7

Source: Herdt (1976), table 6.

[a]M2, M3, M4 and M5 are increasingly higher combinations of input management packages.

[b]Note that for the dry season at the majority of centers the economic optimum yield increase exceeds the yield gap shown in table III.11. At several centers this may partly reflect a change in sample size, but in general is due to the point raised in footnote (a) in tables III.10 and III.11.

for higher levels of input use in the wet season would appear to be modest with the present capital stock and levels of managerial ability.

In the dry season, however, there does appear to be a marked economic potential for increasing input use and yields. This is clearly demonstrated by the lower half of table III.12. Only in Laguna in 1975, Camarines Sur in 1975, and Supan Buri was the economic optimum input level below the high input level associated with potential yields. For the other locations, it appears that it would have been economic to increase input levels above those classified as high. Thus, for these areas the "potential" level would have been economically feasible, as would even higher levels, had they been within the managerial scope of the farmers. While this clearly suggests that there is appreciable scope for increasing input use and rice yields in the dry season, it must be emphasized that dry season irrigated acreage is comparatively small in relation to wet season acreage. Indeed, from the data presented in table III.9, it can be calculated that in the dry season, only 5.8 million hectares out of the wet season total of 78.3 million were cropped to rice.

While the technique of IRRI yield gap analysis summarized above provides a framework for quantifying the effects of constraints to the adoption of technology, it does not directly identify factors contributing to the constraints. It is true that in defining the high level of inputs the analysis hypothesizes a management constraint. A noteworthy implication of the research is that it may be worth placing more policy emphasis on raising managerial capacities. Also, in calculating the economic optimal management system the analysis has addressed the concept of an economic constraint, but to the extent that farmers were operating below this level, it alone does not adequately explain farmers' behavior. Traditional farm level surveys conducted by IRRI researchers have identified many reasons why farmers have not adopted economically profitable input levels, along with other constraints. The dominant constraints which emerged were unavailability of input credit or its high cost, problems of obtaining timely deliveries of inputs, poor water control, perceived risk of crop failure, and lack of knowledge concerning appropriate input levels due to lack of education and/or infrequent attention by extension agents. The significant thing about these major constraints is that they are outside the control of farmers, and do not imply inefficiency or ineptitude on the part of farmers. It is, however, within the realm of policy to expand credit facilities, improve the input supply system, and strengthen extension services, although IRRI research possibly implies that the returns to such policy developments might be modest.

The methodology developed by IRRI makes a major contribution to the understanding of the constraints issue. However it does not explore all aspects of the system constraining the adoption of new technology by farmers. Notably it does not address the reasons which cause farmers not to adopt modern rice varieties.

The IRRI gap measurement assumed that farmers were using MV, and more probably, that a single MV would be considered appropriate on any given farm. The Nepalese research centered on farmers' decision making relative to selection of an appropriate improved variety, and how farmers fitted the new variety into their particular farming system. The results were from actual farm interviews, and there was no pre-conceived notion of "the most appropriate variety" or that a single variety would be used on a farm. It is therefore in no way a controlled experiment, but rather a "probing" of what actually takes place on farms of different sizes and with varying resource endowments.

Adoption of Rice Technology in a Nepalese Village

During the 1977/78 crop year, Douglas Pachico (1979) worked closely with a sample of 90 Nepalese farmers in the Village of Sanga, in an effort to gain a more complete appreciation of their rationale for adopting technology which would increase rice yields and production. The village of Sanga is in some respects advantaged compared to most villages in the hills of Nepal, even though farm sizes are quite small and per capita income low by standards of international comparison. The village is located on a hillside, at an elevation of approximately 4,800 feet, overlooking the valley of the Punimata River. Bordered on the south by the Arniko Highway which runs from Kathamandu to the Tibetan border, Sanga is about one mile from the important market town of Banepa, and an hour and a half by bus from the capital, Kathmandu. The village, therefore, has excellent access to markets in both Banepa and Kathmandu.

Proximity to market centers contributes to the ability of farmers to participate in the high cash flow agriculture associated with the extensive use of new technology. All sample farmers purchase fertilizer and all use MV on at least some of their land. This is possible because agroinputs are readily available in Banepa, and also because it is easy to market surplus production there.

Many farm families in Sanga also have members participating in the non-agricultural labor market. This is, of course, facilitated by the nearness of the urban labor market, and the resulting increased cash flow allows the purchase of inputs associated with the new agricultural technology. Since the village is densely populated and the forest of the surrounding higher slopes has been completely cut down, villagers in Sanga must buy most of their firewood. Thus, part of the high cash income in this village is expended on a commodity which is typically obtained in most hill villages by means of family labor in the slack season.

The lack of forest land and public pasture limits the production of livestock to that which can be supported by farm resources. This limitation, coupled with the small farm size, has led to the almost complete disappearance of draft animals in Sanga. As a consequence, most land preparation is done by hoe.

The village, then, represents something of an anomaly in Nepal today: a high proportion of lowland, good access to roads and markets, high cash flow, extensive use of new technologies, no public forests or pasture, and very little draft power. In some respects, this village can be seen to represent what might be the future for other areas of the hills. Transportation and marketing opportunities have been improving due to government investment in infrastructures, while forests and pastures are fast being cut down, overgrazed, or lost through erosion. Sanga is interesting in that it offers some possibilities for development that could occur on small farms in the hills, despite the loss of forest and pastures, given better access to markets and new technologies.

While all farms in this village share the same general environment, not only with respect to climate, but also in terms of access to markets and lack of public pasture land, important differences in resource endowments do exist among the farms which limit the choices farmers can make regarding the selection of new technology.

Table III.13 shows the percentage of sample farm households in the village falling into six size categories, along with the percentage of land that is irrigated lowland, rainfed lowland, and upland. Average farm size is 0.65 hectares, almost identical to the average of 0.60 for the eastern hills of Nepal, but well over half the sample farms own holdings less than 0.50 hectares and the largest farm is less than three hectares. There is, then, a clear inequality in the distribution of land ownership, with the bottom 55 percent of households owning only 19 percent of the land, and the top 16 percent owning 47 percent.

By Nepalese hill standards, the farmers in this village have relatively high quality land. For the entire sample almost three-fourths of all land is lowland, though the farms in the smallest size strata own the highest proportion of poor quality upland. The farms in the largest size category own the highest proportion of irrigated lowland, the best quality land.

The distribution of operated holdings is more equitable than the distribution of ownership due to the rental market in land. A comparison of the percent of total land owned and total land operated by farmers of

TABLE III.13.--Characteristics of Sample Farms, Sanga, Nepal, 1978

Land owned	Average family size	Land owned ha	Percent of land irrigated lowland	Percent of land rainfed lowland	Percent of land upland	Average operated holding ha	Percent of sample households	Percent of sample land owned	Percent of sample land operated
0- .25 ha	5.2	.10	22	32	46	.23	33	5	12
.26- .50 ha	6.6	.40	24	52	24	.42	22	14	14
.51- .75 ha	6.7	.59	29	49	22	.60	11	10	10
.76-1.00 ha	9.6	.86	26	46	28	.88	18	24	24
1.01-2.00 ha	11.1	1.42	23	49	28	1.39	10	22	21
More than 2.00 ha	13.0	2.92	45	31	24	2.28	6	25	19

Source: Pachico (1979), table IV-1.

each land size category in table III.13, reveals that the impact of the rental market is to shift land from farms greater than two hectares to farms less than 0.25 hectares, while farms in the other size groups are scarcely affected. Rental is on a share crop basis with one-half of the crop customarily going to the landlord. All expenses of production are borne by the tenant with the occasional exception being that landlords may provide seed.

The percent of total income by source for farms of different size groups is shown in table III.14. Levels of cash income vary between farms of different resource bases. Not surprisingly, the largest farms, which have the highest per capita income, also have the highest per capita cash income. While the medium and small-size farms have lower per capita levels of cash income, the percent of total income received in cash by these farms is only slightly less than for the large farms. It should be noted that cash income is not only a component of farm family welfare; it also influences the ability of farms to use technologies involving substantial purchases of inputs.

Large farms have very high per capita cash income from sales of crops, but only moderate income from wages and sales of livestock. Due to the low man/land ratio, large farms were able to sell 41 percent of their total crop output. In contrast, small farms, whose crop production is primarily a subsistence activity, sold only 12 percent of their crop output, while middle-size farms sold 21 percent.

While at first it appears that all the farms are similar, given their small size, important distinctions do exist in the resource base

TABLE III.14.--Proportion of Total Income Derived from Farm and Non-Farm Activities, Sanga, Nepal, 1977-78

	Crop Y As % of Total Y	Live Y As % of Total Y	Wage Y As % of Total Y
S	58	19	22
M	61	28	11
L	71	20	9
All	64	23	14

Source: Pachico (1979), table IV-3.

(quality and amount of land) among farms in terms of per capita cultivatable land. These differences are reflected in the relative importance of crop production, livestock, and wage labor as sources of income for farms in the three size categories. Differences in resource base determine whether farms engage in subsistence or commercial crop production, and hence determine their ability to purchase those inputs necessary to the implementation of new technologies.

The relative proportions of land cultivated by farms in the different size categories and allocated to these crops are presented in table III.15. The main monsoon crops, rice and maize, are planted in all fields by all farmers in all size groups. Winter wheat is grown by all farmers on over 90 percent of the lowland, but as farm sizes increase, the area planted to wheat decreases and the area planted to potatoes rises slightly. Millet cultivation is associated with small farms, while soybeans, an alternative to millet, are more often grown on larger farms. Mustard, another alternative to millet, is likewise grown by a higher percentage of farmers on a greater proportion of land among the larger farms. Rice followed by wheat is the main lowland rotation in Sanga, while the two important upland rotations are maize with a relay crop of finger millet, or maize intercropped with soybeans, sometimes followed with a crop of mustard.

The planting and harvesting dates of the crops are staggered. Maize is planted from late April to early May on the upland fields, and from late May to early June, wheat is harvested on the lowland fields. In late June and early July rice is transplanted into the lowland fields, while millet

TABLE III.15.--Percent of Lowland and Upland Planted to Various Crops, Sanga, Nepal, 1977-78

Farm Size	Lowland			Upland		
	Rice	Wheat	Potatoes	Maize	Millet	Mustard
0 - .50 ha	100	97	3	100	88	2
.51 - 1.00 ha	100	97	3	100	76	2
1.01 + ha	100	94	5	100	58	13

Source: Pachico (1979), table IV-6.

is transplanted into the upland fields about a month later. By the middle of September, maize and soybeans have been harvested. Mustard is planted in late September and a month later the rice harvest begins, extending from mid-October to mid-November. In late November mustard and millet are harvested, while wheat is planted in late November through early December. Planting, harvesting, and threshing for the different crops grown in this system are arranged so as not to coincide with peak labor demand for tillage. This permits farmers to distribute their labor more evenly through the crop year.

All sample farms have a complex interlocking of agricultural enterprises based on utilization of labor on various upland and lowland crops. One important consequence of this pattern of interlocking labor requirements is that changes in the timing of operations on any major field crop, either upland or lowland, may have important effects on the total requirement of labor for the whole farm. New crop variations, technologies, or rotations which alter the timing of major operations and seriously disrupt the pattern of labor requirements, may not be readily accepted by farmers even if the new practice is apparently superior.

The discussion of Sanga has so far described the general characteristics of the farming system, the profile of farm resource endowments, and the major crop rotations and labor cycle. This discussion has established a background for a detailed analysis of choices between alternative technologies. Examination of farmer decision making permits a fuller understanding of the relationship between farm resources and farm practices.

Rice Production and Technology. Rice is cultivated in all lowland fields in the monsoon season and it is the single most important crop in Sanga with respect to total production and value of sales. The general methods of rice husbandry are fairly similar among all farms. The seedbeds for the paddy rice are prepared in late April and early May. After the winter crop of wheat is harvested in June, the paddy fields are tilled with hoes and compost is applied. In late June and early July, the paddy is transplanted into the flooded fields. The rice crop is hand weeded, usually twice, during August and September. Throughout this period the rice fields are tended regularly to control the water level in the fields and to repair the bunds. In late October and early November, the rice crop is harvested by hand with sickles and threshed by flailing the grain on stones.

One of the main foci of decision for farmers in rice production in this village is the choice of rice variety to be cultivated. Three principal rice varieties are grown in Sanga. Taichin is a nitrogen-responsive dwarf variety that has been imported from Taiwan and introduced into Sanga by the government agricultural extension service. Table III.16 indicates that 84 percent of the farmers grow Taichin on 50 percent of the area cropped to rice. Average yields reported by farmers are very high, in excess of 4.6 metric tons per hectare.

Pokhareli, the other major rice variety in this area, is believed to be indigenous to the hills of western Nepal and has spread among farmers since its introduction into this area about a decade ago. Pokhareli is grown by 58 percent of the farmers on 40 percent of the area cropped

TABLE III.16.--Adoption of Three Rice Varieties--Proportion of Farms Growing, Area Cropped and Production, Sanga, Nepal, 1977-78

	Taichin	Pokhareli	Thapachinia
Percent of farms growing	84	70	19
Percent of total area	50	40	10
Percent of total output	57	36	7

Source: Pachico (1979), table IV-7.

to rice. The short, stiff-strawed stature of Taichin allows higher rates of fertilizer application. On sample farms the average use of nitrogen on Taichin was 105 kg/ha, while on Pokhareli it was 67 kg/ha. This resulted in Taichin obtaining yields approximately 20 percent higher than the 3.8 metric ton per hectare average for Pokhareli. The third common variety in the village is Thapachinia, a local variety that was formerly the most commonly grown variety of rice. It is still grown by 20 percent of the farmers on 10 percent of land cropped to rice.

Since Taichin and Pokhareli are grown by most farmers on the majority of lowland, the main choice facing farmers is between these two varieties. Taichin and Pokhareli differ with respect to several characteristics--yield, response to fertilizer, cooking and taste quality, labor requirements, price, milling, cash costs of production, and length of growing season. The choice between the two varieties, therefore, is complex.

It is clear from table III.17 that the decision to plant one or the other variety is strongly related to resource base. Sixty-seven percent of the area on farms smaller than .5 hectares is devoted to Taichin, compared to 31 percent of the area on farms larger than one hectare. Likewise, only 32 percent of the small farms grow Pokhareli, while 100 percent of the large farms grow this variety.

To understand the preference of small farmers for Taichin, it is first necessary to consider differences in labor requirements between the two varieties. Labor per hectare for the production of Taichin and Pokhareli is given in table III.18. These data are based on the average reported labor inputs from sample farms and show that there is little

TABLE III.17.--Relationship of Adoption of Rice Varieties to Farm Size, Sanga, Nepal, 1977-78

	Taichin	Pokhareli	Thapachinia
0 - .50 ha	71	24	5
.51 - 1.00 ha	59	35	6
1.01 ha	31	52	17

Source: Pachico (1979), table IV-8.

TABLE III.18.--Labor Use by Rice Varieties, Sanga, Nepal, 1977-78

	Taichin	Pokhareli
Cultivation	129	129
Transplant	55	83
Weed	79	79
Tie plant	0	15
Harvest/thresh	138	85
Total	401	391

Source: Pachico (1979), table IV-9.

difference in the total labor requirements of the two varieties. However, Taichin requires more labor in harvesting and in carrying the harvest from field to home because of its greater yields. The major labor difference between the two is in threshing. While Taichin, a Japonica variety, is very difficult to thresh, Pokhareli threshes quite easily and is, in fact, subject to grain being dislodged from the plant while still in the fields. During field research shortly before harvest in 1977, rainfall caused considerable shattering in the Pokhareli fields; no damage was visible in the fields of Taichin. The greater labor required for threshing Taichin can be obviated to some extent by the use of pedal operated threshing machines marketed by the government Agricultural Input Corporation. None of these machines were owned or used by farmers in the sample, however.

Pokhareli requires more labor than Taichin in only two operations. First, since it tillars less than Taichin, Pokhareli is planted at a higher density, thus requiring more labor at transplanting. Second, unlike the dwarf Taichin, Pokhareli is susceptible to lodging at current rates of fertilizer application. To counteract this tendency farmers must bind the Pokhareli plants together for support about a month before harvest. This operation is not performed on Taichin or Thapachinia.

While Taichin production requires only 3 percent more total labor days than does Pokhareli production, the rupee cost of labor for producing Taichin is approximately 10 percent higher than the cost of labor for Pokhareli. This is due to the fact that the operations in which Pokhareli requires more labor, transplanting and tying plants, are done by women, who receive lower wages than men. Threshing is done by males, and men participate in harvesting and predominate in carrying, so the operations for which Taichin requires additional labor are largely done by the higher paid males.

Not only is the total labor demand for producing Taichin greater and more costly, but the operations for which additional labor is required come at a more inconvenient time than do the operations for which Pokhareli needs extra labor. Wheat is planted almost immediately after rice harvest; therefore, if a farmer runs short of labor at rice harvest because of the extra requirements of Taichin, wheat plantings may have to be delayed. Wheat yields are adversely affected by tardy planting, and a late wheat crop will be harvested late, thereby interfering with land preparation for the next rice planting. Thus, due to the rapid turn-around time associated with the intensive double cropping that prevails in the lowland fields in this village, a labor shortage at rice harvest can quite seriously disrupt the timing of other lowland operations.

Though Pokhareli requires more labor at spring planting, the supply of labor for hire may be higher at this time than in the fall, since workers come down from nearby high altitude villages to work in the rice planting in Sanga and the surrounding areas. Seasonal laborers also come in the fall for the rice harvest, but local farmers maintain that labor is more plentiful in the spring because poor families may have exhausted their store of the previous fall's crop and are, therefore, in serious need of income. The harvest of upland maize, however, occurs prior to rice harvest in Sanga, so poor high altitude farmers will have an ample short term food supply from maize in the fall and thus be less motivated to seek out seasonal employment.

All of the large farms sampled hired labor for rice production, while only 42 percent of small farms hire labor. Of the small farms hiring labor for rice production, two-thirds have no male family laborers between the ages of 18 and 45, and for an additional one-fifth, all males aged 18 to 45 have off-farm employment. It may be concluded that except for a minor proportion of small farms which face a family labor shortage due to the age composition of the family or off-farm employment, small farms supply their own labor for rice production. The peak periods of labor demand for Taichin come at a time when hired labor is scarce, and as was mentioned above, a labor shortage can severely disrupt key operations in a highly interrelated crop rotation. Since small farms usually have more available labor per hectare of crop land than large farms, the small farmer is more likely to grow Taichin than the large farmer. It should be noted, however, that Pokhareli commands a higher price than Taichin due to consumer preference for long grained rice.

Data on 90 farms in Sanga were collected which allow a comparison of the cash costs, receipts, and net income for the two varieties on farms in each size category. To simplify analysis, farms were divided into those which hire no labor (small subsistence) and the larger (commercial) farms, which hire a significant amount of labor. Budgets show that for both small and large farms the net returns per hectare for Taichin exceed those of Pokhareli, and net returns per hectare for either variety are greater for small farms than large farms. This is primarily due to the cost of hired labor; however, it is also interesting to note that smaller farmers achieve higher yields per hectare despite poorer land quality.

This is consistent with Hart's findings in Village A. The additional returns from growing Taichin are greater for small farmers in absolute terms, as well as when profitability is expressed as returns on additional investment, such as fertilizer.

The tendency of small farmers to plant a greater proportion of area to Taichin than large farmers results, in part, because small farmers are more oriented to raising returns per hectare, since for them land is a more scarce factor than labor. Small farmers tend to rent land in, and many hire their labor out, while only few hire labor in. For large farmers, on the other hand, labor is more scarce than land. Large farmers rent land out, hire labor in, and do not engage in off-farm agricultural employment. Thus, large farms are growing Pokhareli despite lower per hectare returns because the additional net return per hectare from Taichin is small relative to the additional cost, while the return on labor, or its more general equivalent, variable capital, is greater on Pokhareli. Furthermore, because the large farmer must hire labor, total investment in Taichin is much greater than it is for Pokhareli. Growing Taichin also increases risk for the larger farmer, since there is a greater initial investment to be lost if the crop fails.

Another factor to be considered in the decision to grow Taichin or Pokhareli is that farmers may not all value output at its market price. The small farmers who grow primarily Taichin, sell very little of their output. In contrast, large farmers growing mainly Pokhareli sell most of their output; in fact, the percentage of all Pokhareli produced by farms of all sizes that is sold is greater than the percentage of all Taichin sold. For the small farmer Taichin is far more attractive as a subsistence crop than Pokhareli, since it yields about 50 percent more edible grain per hectare after cash costs of production have been met.

These differences express the logic of why small farmers grow a higher proportion of Taichin, but it is also interesting to consider why large farmers may also grow some Taichin. For one thing, growing several varieties does provide farmers with some protection against risk. Farmers note, for example, that though Pokhareli is more susceptible to losses from shattering, Taichin is more susceptible to insect damage. Large farmers, with more fields and less need to maximize per hectare output of foodgrain to meet subsistence needs, are able to diversify and thereby reduce risk.

Large farmers also grow Taichin to feed hired workers a meal at mid-day; since Pokhareli has a higher selling price, farmers prefer to feed their workers the cheaper Taichin. Although Taichin is considered inferior as a cooked rice, and is not usually eaten cooked by prosperous farmers, when flattened and served as an uncooked snack, the difference in quality is not noticed.

So far this discussion of farmers' choices of varieties of rice has ignored the role of Thapachinia, the main traditional variety of rice. About 76 percent of the area reported cultivated to Thapachinia is among farms greater than one hectare, though only 10 percent of the area available for rice cultivation is planted with this variety.

Large farmers grow some Thapachinia as part of their diversification strategy and because they can afford to indulge their preference for the traditional variety. Thapachinia's short growing season also makes it somewhat attractive for large farmers. Thapachinia matures in 100 days, compared with 120-125 for Taichin, and 130-135 for Pokhareli. Thapachinia, therefore, is usually mature by the time of the major fall festivals, while the other varieties are not. Since farmers prefer to have some new rice to consume at the festivals, large farmers may also grow Thapachinia for festival season sales.

It is not uncommon for small farmers to grow a band of Thapachinia along the outside edge of a rice field that is planted to another variety. This strip of Thapachinia around the perimeter of the field provides small farmers with some rice for the festival season and also helps in draining the fields. In order to speed ripening and to facilitate harvest, many farmers drain the standing water out of their fields one to two weeks before harvest. The Thapachinia planted along the perimeter of the field can be harvested, allowing a drainage trench to be dug in its place.

Thus far, the discussion of farmer decision making concerning varietal choices of rice has examined how farmers choose from among the varieties of rice available. Farmers must also decide which varieties to grow on which fields. In making this decision farmers usually consult with their neighbors. Since livestock are permitted to graze on the stubble immediately after the harvest, there is considerable danger of damage from livestock if the farmer's neighbors have planted an earlier maturing variety.

Similarly, farmers consult and coordinate dates of planting rice seedbeds and transplanting in order to have fields in a given area ripening at roughly the same time. Coordination of planting dates is also essential because on the terraced hill slopes water drains from upper to lower fields. Water is impounded on the higher fields, which are transplanted first, and disputes over water could occur if a farmer on an upper field delays planting.

This analysis of farmer decision making with respect to rice varieties has led to several important observations. First, it has been shown that the pattern of varietal choice for rice is clearly related to the farm resource base. Second, some of the major decision criteria of small and large farmers have been illuminated. It was noted above that crop production is primarily a subsistence activity for small farmers, and it is clear from the comparison of the major rice varieties that Taichin is the superior variety for subsistence purposes. To a considerable degree, it is preferred by small farmers for this reason. For larger, more commercialized farms, the higher price and higher return on variable expenses make Pokhareli more profitable.

Third, differences in labor requirements are an important determinant of what constitutes an appropriate technology for farms of different resource bases. The greater labor requirement for Taichin presents less of a problem for small farms and is, therefore, more acceptable. Fourth, duration of the crop growing season and the timing of operations are a key element in fitting varieties into this farming system. For example, Thapachinia, a short season variety, is planted late on the rainfed land, yet can be harvested before the other varieties mature. It has for this reason maintained a role in the cropping system despite its lower yield potential. And finally, the importance of timing is seen in the conflict between the high labor demand for Taichin at harvest and the need for a quick turn-around time for wheat planting.

The IRRI research methodology for quantifying yield constraints analyzed in this section and the appraisal of decision making on Nepalese farms are complementary. They broaden the understanding of how farmers reach decisions, and they appear to fortify the position that farmers are rational in their behavior. Readers interested in pursuing the constraints issue further are referred to the Appendix.

One of the most important aspects of both research thrusts lies in the fact that agricultural scientists are taking their research to farmers' fields, rather than operating within the sterile atmosphere of experiment stations. This is an important step and provides encouragement that the complex constraint problem will be understood more completely, thereby paving the way for appropriate policy and increased production.

The Impact of New Technology on Income and Employment

In terms of policy issues relating to the new rice technology, the measurement of its impact upon incomes and employment is central. Actually, it is not the new rice technology as a whole which should be examined, but the separate components of that technology. This is dictated by the fact that not all the elements of new technology are complements; some are in fact, substitutes, which is the main reason for policy controversies. In general, it often proves too difficult to disentangle the separate effects of new varieties, fertilizers, pumpsets, tractors, etc., and some compromise is necessary. Such compromises have certainly been adopted by Ranade (1977) and Doraswamy (1979), both of whom address the problem.

Ranade's comprehensive study examined the combined effect of all the technological changes in rice production upon employment and the shares paid to different factors and socioeconomic groups participating in production. Ranade also considered the changes in production function parameters which occurred during the period of adoption of new varieties. The results of this analysis have been reviewed under "Technical and Economic Efficiency" in this section. In Doraswamy's Indian study, attention is focused upon the impact of mechanization only. Both studies are open to the criticism that the impact they measure may have been influenced by factors other than those of technology. This is inevitable, however, and stems from the absence of data relating to changes in the levels of these other factors. Despite this problem the results remain convincing.

The Impact of Technology in Laguna and Central Luzon

As a preliminary step in analyzing the impact of technological change, Ranade computed the change in the absolute and relative shares of participants (socioeconomic groups participating in production) and of factors of production over the interval 1966 to 1970. The participants in production were identified as landlords, hired labor, operators, and current inputs. Shares were computed as follows:

a. Payment to landlord--value of output given as rent on land minus landlord's production costs.

b. Payment to hired labor--sum for all operations of wage rates times number of mandays worked, plus value of output given to harvesters.

c. Payment to operator--value of output minus the sum of payments to landlord, hired labor, and current inputs.

d. Payment to current inputs--covers expenses for fertilizer, insecticide, pesticide, herbicide, irrigation, and rent of tractors and threshers.

To provide a more comprehensive picture of change in economic flows, the shares of the following factors were defined:

e. Payment to land--payment to landlord *or* imputed cost of land.

f. Payment to labor--payment to hired labor plus imputed value of family labor.

g. Payment to capital--imputed value of capital equipment.

h. Profit of operator--value of output minus (d + e + f + g).

However, since comparable capital data were not available for all the samples, it was not possible to compute payment to capital, and hence instead of operator profit an estimate was made of:

j. Operator's residual--value of output minus (d + e + f).

In Central Luzon, although data were available for 1966, 1970, and 1974, the abnormally bad weather and yield conditions of 1974 distorted calculations for this year and it was omitted from the preliminary analysis; attention was focused on the period 1966 to 1970. This was a period which witnessed the introduction of modern rice varieties on 67 percent of Central Luzon sample farms, and the accompanying spread of tractor and herbicide use to 45 and 40 percent of farms, respectively (see table III.4). In the same period modern varieties were adopted by all farmers in the Laguna sample, accompanied by the spread of tractor use to 71 percent of farms. Since over the interval there was virtually no change in the irrigated area, the observed changes in the distribution of output can be attributed to the increased level of MV use, plus a complementary package of chemicals and also to mechanization.

There was, however, the complicating factor of the land reform in the Philippines. This, as has been reported, effectively reduced average land rents and increased tenants' returns as a consequence of the conversion of share-tenants to leaseholders at controlled rents. In order to correct for this, the data on changes in participants' and factor shares in table III.19 are presented for share-tenants only. Comparable data are presented by Ranade (1977, p. 98; pp. 246-9) for lease-holders in Laguna, and using adjusted data to allow for depressed yields, for owner-operated

TABLE III.19--Allocation of Earnings on Shareholder Operated Farms, Laguna and Central Luzon, Philippines

	Laguna, wet		Laguna, dry		Central Luzon	
	1966	1970	1966	1970	1966	1970
	Real earnings per hectare allocated among earners (m-tons)					
Landlord	.86	1.12	.97	1.14	.80	.71
Hired labor	.54	.88	.58	.77	.42	.55
Operator	.80	.95	.89	1.07	.79	.70
Current inputs	.14	.44	.18	.37	.22	.32
Total = Yield/ha	2.34	3.40	2.60	3.35	2.23	2.28
	Shares allocated among earners					
Landlord	.37	.33	.37	.34	.36	.31
Hired labor	.23	.26	.22	.23	.19	.24
Operator	.34	.28	.34	.32	.35	.31
Current inputs	.06	.13	.07	.11	.10	.14
	Shares allocated among factors					
Land	.37	.33	.37	.34	.36	.31
Labor	.41	.36	.38	.32	.26	.35
Operator's residual	.16	.18	.18	.23	.27	.20
Current inputs	.06	.13	.07	.11	.10	.14

Source: Adapted from Ranade and Herdt (1978), p. 97.

farms in Central Luzon. These figures lend support to the main conclusions drawn from the share-tenant data in table III.19.

Considering first the absolute shares or real earnings of participants, it can be seen that these increased between 1966 and 1970 for all participants in Laguna in both the wet and dry seasons. Thus the higher yields which accrued due to the changes in factor use appear to have benefited all classes of participants. In Central Luzon, however, adverse weather in 1970 meant that average rice yields showed only modest gains between 1966 and 1970. Since there was a substantial increase in the use of modern inputs and labor (see table III.20), plus an increase in real wages over the same interval, it was landlords and operators who bore the cost of the depressed yields and suffered diminished earnings, while the earnings of hired labor and current inputs rose. Had yields been better in 1970, the Central Luzon data might have displayed a picture similar to Laguna, with all participants gaining. In view of the social and distributional issues involved, it is of significance to record that the real earnings of hired labor are shown to have increased between 1966 and 1970.

Against this background of increasing absolute shares, changes in the relative shares of participants and factors show the factor biases of the changes in technology which occurred. It is revealing to note (table III.19) that for both Laguna and Central Luzon, the relative shares of both landlords and operators declined, while those of hired labor and current inputs increased; that is, there is a bias in favor of the latter two categories. At first it might appear that there is some contradiction in

TABLE III.20--Labor Inputs, by Operation, Wages, and Rice Prices, Laguna and Central Luzon, Philippines

Operations	Laguna - all farms				Central Luzon - Adjusted sample and data[a]					
	Labor Input (Mandays/ha)				Labor Input (Mandays/ha)			% Hired Labor		
	Wet Season		Dry Season		Wet Season			Wet Season		
	1965	1970	1966	1970	1966	1970	1974	1966	1970	1974
Land preparation	24.7	16.5	24.3	16.6	20.1	13.8	14.2	16	16	27
Planting	13.2	17.8	11.9	17.3	19.0	24.4	26.4	81	82	79
Weeding	14.4	17.4	17.2	22.3	5.1	13.8	16.7	34	26	47
Fertilizing	0.8	0.9	0.9	1.1	0.6	0.8	1.4	5	4	11
Spraying	0.4	0.9	0.4	1.0	0.7	0.7	1.8	17	4	15
Total preharvest	53.5	53.6	54.8	58.2	45.6	53.4	60.6	44	48	54
Harvesting and threshing	33.4	32.7	32.8	26.1	17.8	17.7	29.1	90	88	94
Total labor	86.9	86.2	87.6	84.4	63.4	71.1	89.7	57	58	67
Current wages[b]	3.95	5.48	3.84	7.17	4.65	5.22	8.40			
Price of Palay[c]	404	447	389	618	423	472	1139			

Source: Ranade (1977), pp. 91, 103, 238.

[a]For details of adjustment see text.
[b]In pesos per manday.
[c]In pesos per m-ton.

the fact that the relative factor shares of labor and the operator's residual change in a direction opposite the relative participants' shares. But this difference is due entirely to the fact that operators reduced their input of family labor in response to higher incomes. This reduction in the percentage share of operator's labor more than offsets the increase in that for hired labor, and causes the relative share of labor as a whole to decline. It also counteracts the percentage increase in operators' residuals, thus causing the relative share of operators' returns to labor, management, and capital to fall.

Additional insight into the factors contributing to the changes in the distribution of output is provided by Ranade's analysis of the impact of mechanization on output distribution (tables III.21 and III.22) and employment (table III.23), and the effect of technological change in general upon employment (table III.20).

It will be noted that the data for Central Luzon in tables III.20, III.21, and III.23 are adjusted for an adjusted sample. The adjustments were made by Ranade to control for the distorting effects of depressed yields in 1970 and 1974, and the fact that in 1970, 30 percent of the sample farms used only traditional varieties.

For 1974, the effect of depressed yields was calculated by asking farmers what they thought their yields would have been without typhoon damage, but with the same amount of inputs. Their responses indicated that about half expected substantially higher yields. In computing the corresponding shares in expected output, it was assumed that the cost of harvesting would increase in proportion to the yield and that share-tenants would have paid landlords correspondingly higher rentals.

TABLE III.21--Changes in Participants' Shares, Factor Shares, and Employment on Mechanized (M) and Non-mechanized (NM) Farms, Wet Season, Laguna, Philippines

	1965 NM	1970 M	1970 NM
	Absolute shares of Participants (m-tons/ha)		
Landlord	0.89	1.06	1.09
Hired labor	0.52	0.78	0.75
Operator	0.96	1.12	1.21
Current inputs	0.11	0.40	0.27
Total = yield/ha	2.48	3.36	3.32
	Percentage shares of Participants in output		
Landlord	36	31	33
Hired labor	21	23	22
Operator	39	33	37
Current inputs	4	12	8
	Absolute shares of factors (m-tons/ha)		
Land	0.93	1.09	1.17
Labor	1.02	1.13	1.25
Operator's residual	0.42	0.74	0.63
Current inputs	0.11	0.40	0.27
	Percentage share of factors		
Land	38	32	35
Labor	41	34	37
Operator's residual	17	22	19
Current inputs	4	12	8
	Changes in employment (mandays)		
Land preparation	27.6	15.2	20.8
Total labor	89.7	85.4	88.8

Source: Ranade (1977), pp. 110, 111, 114.

TABLE III.22--Changes in Participants' and Factor Shares, by Class of Mechanized Farm, Wet Season Adjusted Sample and Data, Central Luzon, Philippines

	Non-mechanized Farms			Farms with Mechanical Threshers			Farms using Tractors			Farms with Tractors and Threshers		
	1966	1970	1974	1966	1970	1974	1966	1970	1974	1966	1970	1974
				Absolute Shares of Participants (Cavans/ha)								
Landlord	11.7	17.9	15.0	15.5	16.1	12.4	21.7	14.7	12.4	10.9	13.7	9.4
Hired labor	11.6	14.8	14.6	6.7	7.0	8.1	15.2	17.0	16.3	5.6	8.3	9.4
Operator	18.0	33.6	27.0	24.9	32.2	48.0	20.6	28.9	36.1	21.2	34.9	43.0
Current inputs	1.7	5.3	7.6	4.8	5.4	9.9	5.5	7.7	10.9	8.5	10.6	11.9
Total = Yield/ha	43.0	71.6	64.2	51.9	60.7	78.4	63.0	68.3	75.7	46.2	67.5	73.3
				Percentage Shares of Participants in Output								
Landlord	27.3	25.0	23.3	29.8	26.5	15.8	34.4	21.5	16.4	23.6	20.4	12.8
Hired labor	27.0	20.7	22.8	12.9	11.6	10.4	24.2	24.9	21.5	12.0	12.2	12.8
Operator	41.8	46.9	42.1	48.0	53.0	61.2	32.7	42.4	47.6	45.9	51.7	58.3
Current inputs	3.9	7.4	11.8	9.3	9.0	12.6	8.7	11.3	14.4	18.5	15.7	16.2
				Absolute Shares of Factors (Cavans/ha)								
Land	12.6	17.9	16.8	18.5	17.2	14.6	21.7	14.7	15.0	16.3	16.9	12.6
Labor	20.9	30.6	26.7	12.7	14.4	13.3	21.6	23.8	19.6	9.5	13.0	14.7
Operator's residual	7.8	17.8	13.0	16.0	23.8	40.6	14.3	22.1	30.2	11.8	27.0	34.6
Current inputs	1.7	5.3	7.6	4.8	5.4	9.9	5.5	7.7	10.9	8.5	10.6	11.9
				Percentage Shares of Factors in Output								
Land	29.3	25.0	26.3	35.6	28.2	18.6	34.4	21.5	19.8	35.4	25.0	17.0
Labor	48.7	42.7	41.6	24.4	23.6	16.9	34.3	34.9	25.9	20.6	19.2	19.9
Operator's residual	18.1	24.9	20.3	30.7	39.2	51.8	22.6	32.4	39.8	25.5	40.0	46.9
Current inputs	3.9	7.4	11.8	9.3	9.0	12.6	8.7	11.3	14.4	18.5	15.7	16.2

Source: Adapted from Ranade (1977).

TABLE III.23--Labor Input by Operation, and Current Wages, by Class of Mechanized Farm, for the Adjusted Sample and Data Wet Season, Central Luzon, Philippines

Operations	Non-Mechanized Farms			Farms with Mechanical Threshers			Farms Using Tractors			Farms with Threshers & Tractors		
	1966	1970	1974	1966	1970	1974	1966	1970	1974	1966	1970	1974
Land preparation	19.3	19.1	21.8	21.0	15.9	18.0	21.3	11.4	10.0	9.1	10.1	11.2
Planting	17.0	20.9	31.0	19.9	22.4	23.6	17.9	23.8	25.7	19.0	28.6	31.1
Weeding	3.7	17.1	23.0	4.7	11.4	14.6	8.0	20.0	17.3	9.6	10.8	13.5
Fertilizing	1.0	1.1	1.9	0.5	0.6	1.6	0.7	1.4	1.3	0.7	0.7	1.0
Spraying	0.9	0.5	3.3	0.6	0.8	1.5	1.0	0.8	1.8	0.1	0.6	1.0
Harvesting & threshing	22.0	18.5	30.5	14.0	14.6	19.5	30.5	24.8	38.8	12.7	16.2	16.3
Total Labor	63.9	77.1	111.6	60.7	65.6	78.6	79.3	82.1	94.8	51.2	67.0	74.1
Current wage (pesos/manday)	6.0	8.1	10.9	3.9	4.9	6.6	5.4	5.2	8.6	3.3	4.1	8.3
Yield (cav/ha)	43.0	71.6	64.1	51.9	60.8	78.4	63.0	68.3	75.7	46.2	67.5	73.7

Source: Ranade (1977).

For 1970, there is no information about expected yields on the 10 percent of farms which suffered crop damage; therefore, these farms were excluded from the analysis. Observations on those farms where only local varieties were grown were likewise excluded. The resultant sample sizes for 1966, 1970, and 1976 are 70, 50, and 66 farms, respectively.

Given that in Laguna there were no mechanical threshers, and that mechanization is therefore limited to employment of tractors for land preparation, the main implications of all these results can be summarized as follows:

--The use of tractors for land preparation reduces labor demand for this purpose, and is labor-substituting.

--Total labor demand per hectare on farms using tractors may be even higher than on those which are non-mechanized. This is because farms using tractors exhibited more labor demand for planting and weeding, and greater demand for harvesting labor. Neither of these two differences can, however, be classed as tractor effects. The first was probably due to improved husbandry practices, such as adoption of straight-line planting and row-by-row weeding. The reason for the second effect is unclear, since the evidence is not sufficient to suggest that it was due to higher yields.

--Although tractor farms hired more labor in total, the average wage rate was lower than on non-mechanized farms (and even lower still on farms using threshers). As a consequence, the absolute share or earnings of labor (hired plus operator-supplied) was lower than on non-mechanized farms, with the consequence that labor's relative share was also reduced.

--The last conclusion does not, however, hold for hired labor. As table III.20 indicates, hired labor forms a much smaller proportion of land preparation labor than it does of labor for planting, threshing, and harvesting. Thus the consequence of the fact that tractorization reduced labor demand for land preparation, but increased it for the other operations, was a net increase in hired labor demand. This appears to have been sufficiently large to off-set the lower average wage rate and to result in increases in the absolute and relative shares of hired labor; this is certainly indicated by the Laguna data (table III.21) and also gets some support from the Central Luzon data (table III.22).

--In Central Luzon the shares of operators and their residuals were appreciably higher on farms employing tractors than on non-mechanized farms.

--The use of mechanical threshers in Central Luzon reduced labor demand by more than the adoption of tractors (see table III.23). In all three years total labor demand on farms using threshers was more than 15 mandays per hectare lower than on farms with tractors only, and it was markedly lower in 1970 and 1974 than on non-mechanized farms.

--Because hired labor constituted a high proportion of harvesting and threshing labor, the employment effect of threshers fell mainly on hired labor. This contrasts with the effects of tractors, and suggests that the effects of threshers upon income distribution are much less socially desirable than those of tractors.

--When the reduced demand for hired and total labor is combined with the low wage rate on farms with threshers, the absolute and relative shares of hired and total labor were depressed to much lower levels than on tractor and non-mechanized farms.

--The use of threshers was also associated with markedly higher shares to operators and in the operator's residual than on farms with tractors only, or with no mechanization. This suggests the existence of a strong private incentive for the adoption of threshers in Central Luzon.

--Given the results just summarized, it is not surprising that farms with both tractors and threshers exhibit employment and output distribution patterns which are very similar to those of farms with threshers only. That is, the effect of thresher use is dominant as a result of its depressing effect upon employment of hired labor.

--There is no evidence for the Laguna and Central Luzon samples which would permit refutation of the hypothesis that mechanization <u>does not</u> increase yields per hectare per crop.

--In the case of data for the Laguna wet season, it is recorded (table III.21) that both mechanized and non-mechanized farms had virtually equal average rice yields in 1970, and that these were approximately 20 cavans per hectare higher than those for non-mechanized farms in 1966.

--For Central Luzon (table III.23) there is no evidence that any of the four classes of farms had consistently higher yields than any other. In 1966, it was the sample of farms using tractors only, which recorded the highest yields; in 1970 it was the non-mechanized farms; and in 1974, those with threshers only.

The Impact of Tractors in Chittoor District, India

In examining the impact of new technology in Chittoor District, Doraswamy has confined attention to the effects of tractor adoption, and has furthermore concentrated on the effect on labor employment. The analytical procedure employed has had to contend with the fact that the small sample of farms is exceptionally heterogeneous. It will be recalled that the sample comprises four subsamples, one for each of four clusters of villages in different taluks. Also, as reported in table III.24, there is a diversity of crops in each of the subsamples and there are major differences in crop composition between the subsamples. Thus the sample is small relative to the range of farm conditions covered. This is well illustrated by the data in table III.24, which indicate the number of farms in each of three mechanization classes (defined below) growing any particular crop in each of the four centers; the majority of cell values are less than five even for major crops, and many are zero.

Doraswamy's analysis of this question was conducted in three stages. In the first, he attempted to measure the impact of tractor use on "labor intensity," or the amounts of labor used for each of a number of specified operations in the production of each crop. However, since mechanization

TABLE III.24--Number of Farms Raising Each Crop with Different Levels of Mechanized Technology in the Individual Centers, Chittoor District, India

Crop	Madanapalle			Pedda Kannali			Chittoor			Aragonda		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Traditional paddy	2	5	2	0	8	9	4	12	4	4	8	4
MV paddy	3	16	6	1	10	9	2	8	4	4	11	3
Other food grains	2	8	0	1	14	8	3	5	2	1	2	2
Sugar cane	0	3	1	0	0	0	4	14	6	4	13	6
Ground nut	2	8	4	1	14	10	3	10	6	4	12	5
Vegetables	2	13	1	1	1	2	0	6	5	3	7	4
Seed, bajra/jowar	0	9	4	0	0	3	0	0	0	0	0	0
Green fodder	1	2	0	0	0	0	0	0	0	0	0	0
Plantains/betal	0	0	0	0	0	0	0	1	1	0	1	0
Number of farms	3	16	6	1	14	10	6	14	6	4	13	6

Source: Doraswamy (1979).

Note: figures under columns (1) refer to farms with first level of mechanized technology.
" (2) " second "
" (3) " third "

may also affect the proportions in which crops are grown, the second stage of analysis attempted to identify the effect of mechanization upon cropping patterns. In the final stage the combined labor-use effects of the adoption of tractorization upon labor intensity and cropping patterns were computed.

The Effect on Labor Intensity. The analytical procedure adopted was analysis of variance by means of a type of stepwise multiple regression. Separate analyses were conducted for each major crop operation at each of the four centers, where the crop operations were (1) plowing, (2) planting/sowing and pre-planting/sowing operations, (3) maintenance, (4) harvesting and post-harvesting operations, and (5) all operations. The dependent variable was the number of hours labor per acre in each of the above five operations for each of nine crops (shown in table III.24).

For each separate series of stepwise regressions the intercept was suppressed and the potential explanatory variables were:

(1) nine dummy variables for the nine crops;

(2) two dummy variables for the three classes of mechanization; and

(3) sixteen variables to allow for interactions between crops and mechanization levels.

In some centers certain crops were not grown at all, or were not grown by the sampled farms within a particular mechanization class, and this permitted a reduction in the number of explanatory variables from those listed above.

Farms were classified into mechanization classes as follows:

Class 1--Farms not owning or hiring tractors. There were only 14 bullock-only farms in the sample of 99.

Class 2--The 57 sample farms which hired tractors for plowing or other crop production operations.

Class 3--This is made up of the 28 sample farms which owned tractors, either jointly or solely.

It is relevant to note that the main use to which tractors are put in this area is plowing. On Class 2 farms, 67 percent of all tractor hours hired were for plowing, and a high proportion of the remaining hours were for transport. The same holds true for Class 3 farms, except that these farms employ tractors at a much higher level in these operations, displacing more bullocks and labor. The impact of tractorization then, can be expected to show up on plowing labor if it is to be found at all. This expectation is sharpened by inspection of the labor-use data (aggregated over all four centers) presented in table III.25. It can be seen that for virtually all crops plowing labor-use declines progressively as one moves from Class 1 farms to Class 3. (Note that in this District only 5 percent of total labor is used for plowing.) For other operations no general pattern emerges, although for some particular crops and crop operations labor-use does appear to decline with increases in the degree of tractorization. Some of these casually observed effects may be misleading. For example, such a relationship appears to exist for all operations (other than harvesting) for traditional paddy, but this has to be qualified by the fact that the total sample acreage of traditional paddy on non-mechanized farms was only four acres.

TABLE III.25--Crop-wise Labor Use (Hours) per Cropped Acre for Each Farm Operation with Different Levels of Mechanized Technology in All Centers, Chittoor District, India

Crop	Plowing			Planting/sowing			Maintenance			Harvest and post-harvest			All farm operations		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Traditional paddy	74	70	12	286	243	196	388	205	204	208	241	253	956	760	665
MV paddy	77	55	11	288	273	252	285	281	226	273	308	301	922	916	789
Other food grains	63	49	11	172	172	160	193	115	171	165	241	209	593	577	551
Sugar cane	21	14	3	57	90	85	508	610	575	557	615	668	1143	1329	1332
Ground nut	27	23	4	59	64	79	101	148	159	156	117	115	342	351	356
Vegetables	57	35	16	130	112	175	336	244	361	180	261	222	703	653	774
Seed bajra	NG	21	6	NG	190	145	NG	403	339	NG	259	214	NG	873	705
Green fodder	16	18	NG	6	9	NG	0	1	NG	70	63	NG	92	91	NG
Plantains/betal	NG	63	6	NG	147	406	NG	483	561	NG	308	239	NG	956	1212
All crops	40	37	7	126	153	146	318	272	242	328	281	251	812	743	646
Percent of labor used for each operation in total labor use	5	5	1	16	20	23	39	37	37	40	38	39	100	100	100

Source: Doraswamy (1979).

Note: figures under columns (1) refer to farms with first level of mechanized technology.
" (2) " second "
" (3) " third "

Negl: less than one hour.

NG: no sample farm with crop-technology combination.

Multiple regression analysis of the effect of tractors on employment was conducted by successively adding the three blocks of variables. The crop variables were introduced first, then the set of mechanization variables, and lastly the interaction variable. The F-test was used to test whether the blocks of variables were statistically significant as wholes. Naturally, the results indicated that the crops were a significant influence upon inter-crop differences in the amount of labor used in each type of operation. When the two mechanization variables were added, they were found to have a significant depressing influence on plowing labor only at all four centers. While expected in terms of direct effects, the absence of any other statistically significant (positive or negative) effects does suggest that there are no independent factors, such as greater fertilizer use and higher yields on tractor-using farms, which affect labor use in operations other than plowing. Lastly, when the interaction variables were added, they proved to be non-significant in all cases except for plowing at Aragonda, where they were significant at the 1 percent level.

The Effect of Cropping Patterns. An attempt was made to estimate the effect of tractor use upon cropping patterns using multinomial logit analysis to explain inter-farm differences in the proportions of acreage allocated to different crops. The analysis was conducted separately for wet and dry land at each of the four centers, and the original list of crops was reduced to five and three groups, respectively, for this purpose. The five groups for wet land were (1) paddy-traditional plus MV, (2) other foodgrains plus seed bajira/jowar, (3) non-grain food crops, (4) perennial crops plus small acreages of fodder and groundnuts, and (5) unused land. For dry land the three groups were (1) groundnuts, (2) green fodder and perennial crops, and (3) unused land.

Only a very simplified set of variables was used to explain the variations in the proportions of acreage allocated to these crop groups. It was assumed that relative product and factor prices were the same for all farms within each cluster of villages and that such variables would play no role in explaining inter-farm differences. The set of explanatory variables was reduced to (1) the operated acreages of wet and dry land per farm as proxies for liquidity for the purchase of inputs, (2) two dummy variables for Class 2 and Class 3 levels of tractorization, and (3) two interaction terms. In the wet land analysis these are for wet land acreage and mechanization level; in the dry land analysis the interactions are for mechanization and dry land acreage.

Prior to conducting the analysis it was expected that if the use of tractors for plowing showed any effect on cropping patterns it would be for one of two reasons: (1) Because of its effect on timeliness it might permit expansion of the acreage of crops with a short available plowing to sowing interval (this primarily applies to groundnuts on dry land and paddy on wet land) and permit expansion of crops which are highly specific with respect to planting date, and hence tillage date (this applies chiefly to groundnuts on wet lands); and (2) because it reduces labor and bullock requirements for plowing, it might permit expansion of the acreage of paddy which has an especially high demand for plowing time. Therefore, it was anticipated that any crop effects of mechanization would show up largely in increased groundnut and paddy acreages.

The models were tested in a manner analogous to that employed for labor intensity, by estimating equations with progressively more explanatory variables and testing to see if the set of variables added last was statistically significant. Only in two cases, those of the interaction variables for wet land in Pedda Kannali and of the comparable variables for dry land at Chittoor, were the variables as a group found to be non-significant. It was concluded that mechanization did have a significant effect upon cropping patterns on both wet and dry land--although in some cases the coefficients attached to either one or both tractor variables individually were not significant.

The statistical results conformed to expectations best in the case of dry land at Chittoor and Aragonda. No comparable results are recorded for the other two centers because there was no dry land at Pedda Kannali, and at Madanapalle only two out of 25 farmers grew anything other than groundnuts on their dry land acreage. The estimated proportions of land allocated to the different crop groups are presented in table III.26. It can be seen that on farms of average size in both centers, mechanization was estimated to increase groundnut acreage and reduce that of the less labor intensive perennial and fodder crops.

For wet land, as table III.27 indicates, there is not such a clear conformity of the results to expectations. In Madanapalle and Chittoor, mechanization was estimated to be associated with an increase in the proportion of the acreage devoted to paddy. For Madanapalle, the associated changes in the proportion of the acreage devoted to other crops, and particularly the increasing proportion of unused wet land, do not cancel out

TABLE III.26--Estimated Proportion of Area Allocated to Different Crop Groups on Dry Land in Chittoor and Aragonda Centers, Chittoor District, India

	Chittoor			Aragonda		
	(1)	(2)	(3)	(1)	(2)	(3)
Ground nut	0.77	0.78	0.91	0.56	0.95	0.70
Perennial crops	0.20	0.17	0.06	0.20	0.04	0.11
Unused land	0.03	0.05	0.03	0.24	0.01	0.19
Total	1.00	1.00	1.00	1.00	1.00	1.00
Mean Operated Wet Land (acres)		5.59			6.08	
Mean Operated Dry Land (acres)		5.51			5.15	

Source: Doraswamy (1979).

Note: Figures under column (1) refer to farms with 1st level of mechanized technology.
Figures under column (2) refer to farms with 2nd level of mechanized technology.
Figures under column (3) refer to farms with 3rd level of mechanized technology.

TABLE III.27--Estimated Proportion of Area Allocated to Different Crop Groups on Wet Land in Each of the Centers, Chittoor District, India

	Madanapalle			Pedda Kannali			Chittoor			Aragonda		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Paddy	0.29	0.49	0.57	0.32	0.29	0.28	0.08	0.22	0.19	0.20	0.15	0.15
Other Food Grains	0.30	0.25	0.10	0.08	0.12	0.15	0.03	0.02	0.02	0.04	0.01	0.01
Non-Grain Foods	0.24	0.18	0.02	0.25	0.35	0.35	0.87	0.59	0.67	0.69	0.78	0.72
Dry Land Crops On Wet Land	--	--	--	--	--	--	negl.	0	0.01	negl.	negl.	negl.
Unused Land	0.17	0.08	0.31	0.35	0.24	0.22	0.02	0.17	0.11	0.07	0.06	0.12
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mean Operated Wet Land (acres)		6.27			13.02			5.59			6.08	
Mean Operated Dry Land (acres)		3.28			--			5.51			5.15	

Source: Doraswamy (1979).

Negl: negligible (<.005)

Figures under column (1) refer to farms with 1st level mechanized technology.
Figures under column (2) refer to farms with 2nd level mechanized technology.
Figures under column (3) refer to farms with 3rd level mechanized technology.

the labor-creating effects of the shift to more paddy. In Chittoor, however, the combination of estimated changes in the cropping pattern does not lead to additional labor demand. In both Pedda Kannali and Aragonda, the crop effect of mechanization is estimated to be small, the most notable features being (contrary to expectations) a small decline in the paddy acreage and an increase in that of non-grain foods.

In conclusion, it does appear that there is clear, if undramatic evidence that tractorization does influence cropping patterns in Chittoor District, and in the ways which would be expected if time and resources are limited for plowing.

The Combined Labor Intensity and Cropping Effects. The final stage of Doraswamy's analysis of the effect of tractorization was to estimate the combined labor intensity and cropping effects on labor demand. Since tractorization was found to significantly affect only labor demand for plowing, of all the coefficients to labor demand per acre per crop, only its value was assumed to change with the class of mechanization. All the labor-operation coefficients were held constant at their estimated mean values. The average cultivated areas of wet and dry land were also held constant for the three mechanization classes to control against the influence of size effects--the average areas assumed are given in table III.27. Thus the only changes (apart from those in the plowing labor coefficients) which were allowed in response to mechanization were changes in the cropped acreages, which were estimated by applying the proportional changes in acreage presented in tables III.26 and III.27 to the average operated land areas. Applying the variable plowing and other fixed labor coefficients to the resultant acreages for each mechanization level produced the data in table III.28 on the "total" effect of the three levels of mechanization on labor demand. The main points of interest in this table can be summarized as follows:

--In nearly all cases the crop effect of tractor hire and ownership raises demand for plowing labor. The effects are not large and (with the exception of hiring tractors at Madanapalle) are outweighed by the negative labor intensity effect. It does, however, reflect the fact that tractorization was estimated to cause a shift towards crops requiring more resources for plowing.

--The main crop effect is to be observed in the demand for labor for all non-plowing operations. In general, this effect was estimated to be positive. The only exceptions to this were at Chittoor on wet land for both tractor hiring and owning farms, and on wet land at Aragonda for owning farms. At Madanapalle and Pedda Kennali on wet land, and at Chittoor and Aragonda on dry land, there were quite substantial positive effects of cropping changes upon non-plowing labor demand. The largest of these were increases for 28 percent on wet land at Madanapalle and 70 percent on dry land at Aragonda, for tractor hiring farms in both cases.

--Indeed, one of the notable points of the results is that from the point of view of increasing labor hire, the hire of tractors is more favorable than ownership. In all instances except Chittoor

TABLE III.28 Estimates of the Combined 'Labor Intensity' and 'Cropping Effects' of Tractorization on Labor Use, by Mechanization Class and Center, Chittoor District, India

(manhours per farm)

	Madanapalle				Pedda Kannali			
	Plowing Labor		Labor		Plowing Labor		Labor	
	Before crop adjustment	Cropping Effect	All Non-plowing Operations	Total Labor	Before crop Adjustment	Cropping Effect	All Non-plowing Operations	Total Labor
Wet Land								
(1) Class I Farms	564	0	7,443	8,007	1,135	0	9,314	10,449
(2) Class 2 Farms	565	+36	9,502	10,103	672	+86	10,775	11,533
(3) Class 3 Farms	50	+34	7,973	8,057	208	+12	10,765	10,958
(4) Labor change due to tractor hiring	37		2,059	2,096	-377		1,461	1,084
(2) - (1)	(7)		(28)	(26)	(-33)		(16)	(10)
(5) Labor change due to tractor owning	-480		530	50	-915		1,451	536
(3) - (1)	(-85)		(7)	(1)	(-81)		(16)	(5)

(manhours per farm)

	Chittoor				Aragonda			
	Plowing Labor		Labor		Plowing Labor		Labor	
	Before crop adjustment	Cropping Effect	All Non-plowing Operations	Total Labor	Before crop Adjustment	Cropping Effect	All Non-plowing Operations	Total Labor
Wet Land								
(1) Class I Farms	303	0	7,020	7,323	306	0	8,704	9,010
(2) Class 2 Farms	180	+80	6,450	6,710	255	-67	8,765	8,953
(3) Class 3 Farms	39	+ 7	6,711	6,757	40	+ 4	8,262	8,306
(4) Labor change due to tractor hiring	-43		-570	-613	-118		61	-57
(2) - (1)	(-14)		(-8)	(-8)	(-39)		(1)	(-1)
(5) Labor change due to tractor owning	-257		-309	-566	-262		-442	-704
(3) - (1)	(-85)		(-4)	(-8)	(-86)		(-5)	(-8)

(manhours per farm)

	Chittoor				Aragonda			
	Plowing Labor		Labor		Plowing Labor		Labor	
	Before crop adjustment	Cropping Effect	All Non-plowing Operations	Total Labor	Before crop Adjustment	Cropping Effect	All Non-plowing Operations	Total Labor
Dry Land								
(1) Class I Farms	136	0	1,208	1,344	103	0	803	906
(2) Class 2 Farms	30	0	1,222	1,252	23	+16	1,368	1,407
(3) Class 3 Farms	8	+2	1,413	1,423	11	+ 3	1,004	1,018
(4) Labor change due to tractor hiring	-106		14	-92	-64		565	501
(2) - (1)	(-78)		(1)	(-7)	(-62)		(70)	(55)
(5) Labor change due to tractor owning	-126		205	79	-89		201	112
(3) - (1)	(-93)		(17)	(6)	(-86)		(25)	(12)

Source: Doraswamy (1979).

center, ownership of tractors increased total labor demand by less than tractor hiring or depressed it by more.

--Taking all the centers together, tractor hiring led to some increase in total labor demand, but the effect is not marked. No such conclusion is possible for tractor ownership, and it is tempting (but unscientific) to argue that on balance it may have reduced total labor demand.

--In view of the difficulty which is usually encountered in separating the employment effects of tractorization from what are for current purposes independent yield effects, it is important to note that Doraswamy's analysis successfully overcame this and that there are no yield effects included in the estimate in table III.28.

Comment on Effects of Tractor Use

The results just discussed largely confirm expectations based on Ishikawa's view that tractors are not a necessary requirement for increasing rice output in the areas studied. They also fit into the pattern of results presented by Binswanger in his recent review of over one hundred studies of the effects of tractors in South Asia. He concluded:

> The tractor surveys fail to provide evidence that tractors are responsible for substantial increases in intensity, yields, timeliness, and gross returns on farms in India, Pakistan and Nepal. At best, such benefits may exist but are so small that they cannot be detected and statistically supported, even with very massive research efforts. . . . Indeed the fairly consistent view emerging from the surveys largely

> supports the view that tractors are substitutes for labor and bullock power, and thus implies that, at existing and constant wages and bullock costs, tractors fail to be a strong engine of growth. They would gain such a role only under rapidly rising prices of those factors of production which they have the potential to replace. . . . In an environment of stagnant or declining wages, loss of employment may relieve landless laborers of drudgery but it clearly increases rather than reduces their suffering. They have accepted to perform the arduous tasks only because they were forced into them by lack of better alternatives. As long as population growth and slow growth of manufacturing and tertiary sector employment continue to press on rural wages, reducing drudgery is not a social benefit. It merely redistributes benefits from the poorest groups to already richer strata of rural society. (Binswanger, 1978, pp. 73, 75)

It is difficult to add much to this summary. The Cornell/AID studies suggest, in the same vein, that tractors do not cause increased yields or any major changes in cropping patterns, but since in the Central Luzon and Chittoor study areas tractors are employed almost exclusively for plowing, they do reduce demand for bullocks and labor for plowing. In Chittoor there was some evidence to suggest that tractors did not lead to any reduction in total labor demand because the reduction in plowing labor was offset by cropping pattern change-induced increases in demand for other operations. However, even if it is true that with current patterns of use in Chittoor tractors do not reduce total labor demand, it cannot be assumed that this will persist. It can only be anticipated that those owning four-wheeled tractors will try to find additional ways of employing them by acquiring attachments capable of performing operations other than plowing, and that this will reduce labor demand for these operations.

It is worth adding that Ranade's study suggests that the full impact of tractors on the labor market cannot be captured by studying changes in the quantity of labor used. His study found that average wages were also lower on mechanized farms, and therefore that hired laborers may lose from mechanization even though they may be employed for the same period of time. Finally, Ranade's study found, and Binswanger (1978, p. 59) reports the same result for the Punjab, that mechanical threshers have a more severe labor-displacing effect than tractors. Thus threshers appear even less desirable on social cost-benefit grounds than do tractors.

IV. HOUSEHOLD TIME ALLOCATION AND LABOR MARKET OPERATION

The adoption of new technology and the ways in which technical change in agricultural production are diffused into a rural Asian society are importantly affected by decisions within individual households. Few studies have attempted to analyze the motives and motivations behind the ways in which members of a household decide to provide labor in connection with their own assets or for hire to others owning land. In essence, what is being looked at here is an integrated attempt to gain greater insight concerning these inter-relationships.

A detailed study of household time allocation was conducted in the Indonesian study village. Here little new technology has been adopted; consequently the results establish a benchmark or common denominator from which to appraise how labor decisions are made in households located within areas which have adopted varying levels of agricultural technology. Little evidence has been collected relative to time allocation in the Philippino households; however, careful analysis of the ways in which tractor mechanization influences labor allocation in Chittoor District, India, provides an important contrast to the Indonesian study site.

The central focus of Hart's study in Indonesia was on household differences in the allocation of time to different productive activities. Hart was particularly concerned with formulating hypotheses about the determinants of these differences, and developed arguments relating to the significance of the ownership of productive assets in influencing household behavior. Because questions of household time allocation and the structure of operation of labor markets were rightly seen as being interdependent, the two topics will be treated under the same common heading here.

No attempt will be made to review Hart's theoretical model of household time allocation, although this does represent an original contribution. (The interested reader is referred to Hart, 1978, pp. 213-223.) Discussion here is confined to the more relevant empirical findings of Hart's study.

Patterns of Labor Allocation According to Class Status Sex, and Age in Village A, Central Java, Indonesia

This section focuses on inter-class differences in the absolute and proportionate amount of time spent in various income earning activities and housework, and the manner in which household working time is allocated among sex and age groups. (For a description of the classes, see p. 67.) Income earning activities are defined to include work with productive assets owned by the household (rice fields, fishponds, home gardens, and livestock), as well as different types of off-farm work (trading, wage labor, gathering, and fishing). Housework incorporates processing rice for home consumption, food preparation, fetching water, house cleaning, washing clothes, shopping, and house repair/maintenance; however, it excludes time spent in child care activities, which are frequently combined with other housework. There are, furthermore, inter-class differences in the proportion of very young children in the household; therefore, evidence from an intensive sub-survey of child care patterns is discussed separately.

An initial glance at table IV.1 indicates that while the more affluent Class I households on average spend fewer hours in income earning activities, overall inter-class disparities in total working time by the household are quite small. These highly aggregated figures mask some extremely important differences among asset classes. First, it should be borne in mind that from the age of ten children are potentially full time

TABLE IV.1.--Average Hours Worked per Year at Different Job Types, by Class, Sex, and Age, Village A, Central Java, Indonesia

Class		Hours per Household	Hours by Females	Hours by Males	Average Hours per Person: Persons 9 yrs	Girls 10 - 15	Women 16	Boys 10 - 15	Men 16
Own Production[b]	1	3,813	321	3,492	1,048	44	242	508	2,246
	2	1,567	240	1,327	431	44	183	432	839
	3	299	59	240	92	17	46	178	141
Trading[b]	1	615	462	153	171	0	369	0	108
	2	448	418	30	122	43	325	36	1
	3	237	170	67	75	5	132	14	56
Wage Labor[b]	1	552	222	330	153	54	158	52	209
	2	2,798	996	1,802	771	416	641	304	1,291
	3	4,164	1,984	2,180	1,290	1,168	1,202	554	1,706
Gathering[b]	1	65	45	20	19	23	28	22	5
	2	341	224	117	94	172	97	97	45
	3	467	277	191	147	169	162	124	120
Ocean Fishing[b]	1	29	-	29	9	-	-	32	9
	2	582	-	582	160	-	-	421	265
	3	536	-	536	169	-	-	461	290
All Income Earning Activities[b]	1	5,074	1,050	4,024	1,400	121	797	614	2,577
	2	5,736	1,878	3,858	1,578	675	1,246	1,290	2,441
	3	5,703	2,499	3,214	1,773	1,359	1,542	1,331	2,313
Housework[a]	1	1,812	1,666	145	499	362	1,216	31	90
	2	1,589	1,443	146	437	438	1,003	57	82
	3	1,254	1,173	80	390	392	800	37	61
All Activities[b]	1	6,886	2,716	4,169	1,899	483	2,013	645	2,667
	2	7,325	3,321	4,004	2,015	1,113	2,249	1,347	2,523
	3	6,957	3,672	3,294	2,163	1,751	2,342	1,368	2,374
Travel to and from Work	1	713	126	587	nc	nc	nc	nc	nc
	2	723	229	494	nc	nc	nc	nc	nc
	3	690	291	399	nc	nc	nc	nc	nc

Source: Hart (1978), pp. 124, 126, 128.

[a]Hours per male < 10.
[b]Including travelling time.
nc: not calculated.

income earners and that average household size in the landless class is relatively small. Ignoring for the moment distinctions among sex and age groups, if total working hours at the household level are corrected for inter-class differences in household size, there is a consistent inverse relationship between asset status and the amount of time which the average household member over the age of 9 spends in all income earning activities.

There are also marked qualitative differences among classes in the types of income earning activities in which households are involved. As may be seen from table IV.1, a very large proportion of the labor time of Class I households is concentrated in work with productive assets owned by the household. This does not necessarily mean that these more affluent households are engaged in heavy physical work. As defined, working with own assets includes the supervision of hired labor, and in a small number of households, male trading activities. In contrast, landless households (Class III) are primarily involved in heavy manual labor, while the small landholding groups (Class II) occupy an intermediate position. These patterns provide clear support for Hart's theory of household time allocation, which argues that the absolute duration of household income earning time and the proportion of it allocated to off-farm labor, will vary inversely with asset holding.

While the average Class I household spends comparatively long hours in work with productive assets owned by the household, table IV.2 shows that the bulk of this time is spent in fishpond work, an exclusively male activity. One reason for these very long hours is that fishpond owners

TABLE IV.2.--The Allocation of Work among Different Types of Productive Assets Owned by the Household, Village A, Central Java, Indonesia

		Average household hours per year[a]					
		Rice	Fish ponds	Home garden	Tobacco & dryland crops	Live-stock	Total
I	Hours/household	1123.9	2107.8	55.6	113.1	412.2	3812.6
	% allocation	29.5%	55.3%	1.4%	3.0%	10.8%	100%
II	Hours/household	655.6	104.1	71.1	480.8	245.1	1566.7
	% allocation	42.5%	6.6%	4.5%	30.7%	15.6%	100%
III	Hours/household	73.5	0	6.0	32.6	186.8	298.9
	% allocation	24.6%	-	2.0%	10.9%	62.5%	100%

Source: Hart (1978), p. 126.

[a]Including travelling time and supervisory work.

frequently spend all night at the ponds supervising the lucrative nightly shrimp catch, which is sold at a nearby fish market early in the morning. Although owners sleep in huts at the ponds, all time spent there was counted as working time. If the ten fishpond-owning households are excluded, average own-production time in Class I households is reduced considerably.

As may be seen from table IV.1, women perform the bulk of housework, and there is little inter-class variation in the proportionate allocation of housework between females and males. In contrast to income earning activities, there is a strong direct relationship between class status and the absolute and proportionate amount of time devoted to housework, with Class I households spending an average of 44 percent more hours in housework than those in Class III. These differences are even more significant if account is taken of inter-class variations in household technology. The value of kitchen equipment owned by Class I households is substantially higher than that of Classes II and III. In preparing food, Class I households use up to three stoves simultaneously, whereas those in Class III seldom use more than one. Furthermore, both the type of stoves and the cooking utensils used by Class I households are generally more efficient than those used in poorer households. The comparatively high amount of time spent on food preparation in Class I households is attributable to the elaborateness of the meals, as well as the increased number.

Also, hired laborers are occasionally given cooked food in lieu of part of their cash wages. Time spent by Class I women in preparing this food has been included in own-production. This accounts for some of the inter-class disparities in time spent in household activities. A second major source of disparity derives from patterns of shopping. Class I households generally do much of their shopping in the local town where most food prices are 10 to 15 percent lower and the range of goods available is more extensive than in the study village. Wealthier women often spend nearly the whole morning shopping once or twice a week. Landless households, in contrast, do most of their shopping on a daily basis from nearby shops in the village. Shopping is usually done in the late afternoon when income earners have returned from work, and takes no more than a few minutes. While all households sweep and clean every day, increases in household capital are accompanied by a rise in the amount of time spent in housework. There is also a very strong direct relationship between asset status and house size, number of rooms, and the amount of furniture.

There are substantial differences among asset groups in the sex role division of income earning time, with the proportion of income earning work undertaken by women increasing sharply as the household's asset base decreases. This can be seen to hold both at the household level and for individual adult females. The proportion of income earning activity per household performed by females rises from 21 percent of the total in Class I, to 44 percent in Class III, while the per adult female to male ratio of time spent in such activity rises from 31 to 67 percent. In fact, women from landless households on average spend nearly 80 percent of their income earning time in heavy physical labor. Even this may understate the time women are away from home, since in the slack periods of rice production they frequently travel considerable distances from the village to obtain work.

The wage labor contribution of Class II women is concentrated mainly in rice work within the village, and there is a pronounced tendency for them to withdraw from wage labor in periods when demand for rice labor is low. The participation of Class I women in wage labor is minimal, and their off-farm work is chiefly directed to trading, which is by far the most lucrative income earning activity. Of course the high return to trading represents, in part, a return to capital. There is strong reason to suppose, however, that a household's land base is very important in determining access to capital and hence to trading opportunities.

One of the most striking conclusions to be drawn from the data in table IV.1 is the very heavy involvement of girls from the landless class in income earning activities, particularly wage labor. Linking these figures with those for adult women in Class III suggests that a female child born into a landless household is destined to a work pattern which changes very little during the course of her life.

For adult males inter-class differences in the proportionate allocation of labor among different activities are more marked than those for adult females, even though total labor time per adult male shows little difference by class. The direct relationship between asset ownership and labor applied to household assets, and the corresponding inverse relationship between asset ownership and wage labor participation is primarily attributable to adult males. As already noted in connection with table

IV.2, this relationship is strongly influenced by work time spent by 10 fishpond-owning households. Since the positive relationship between the level of assets and labor applied to owned assets outweighs the negative relationship between asset ownership and off-farm work.

The general inverse relationship between assets and total working time is most clearly evident among boys in the 10 to 15 year age group. In comparison with girls, landless boys spend a relatively small porportion of their time in wage labor; this is probably attributable to important differences in the nature of female and male labor markets, which will be discussed more fully below.

As is evident from table IV.3, the limited involvement of boys in the 10-15 year age group from Class I households in income earning activities is directly related to patterns of school attendance. In addition to the relatively high opportunity costs of school attendance by older children (particularly girls) in the landless class, income levels are such that school fees and the cost of books and stationery--particularly for secondary school--represent a heavy burden to poor households.

There is a less direct--but very important--relationship between the role of children in the 6 to 9 year age group in the domestic economy and school attendance. There are some young boys from poorer households who spend quite substantial amounts of time cutting grass for animals, collecting fuel, fetching water and so forth. The proportion of children engaging in these activities is, however, rather small. While children's participation in directly productive work is limited, they are heavily involved in the care of younger siblings and the importance of their contribution to this sphere of domestic organization cannot be overstressed.

TABLE IV.3.--Percentage of Children Attending School, Village A, Central Java, Indonesia

	Annual average		
	Class I	Class II	Class III
Girls 6-9	80.0%	41.8%	38.2%
Boys 6-9	39.6%	47.7%	19.7%
Girls 10-15	64.8%	21.4%	8.7%
Boys 10-15	78.2%	42.4%	24.5%

Source: Hart (1978), p. 138.

Detailed time budgets of households with children under the age of three revealed substantial amounts of time--between 10 and 12 hours a day--devoted to the care of infants and very young children. The child care survey showed that virtually all children from the age of five or six are involved in looking after younger siblings. There are, however, important differences between households in which the mother participated in income earning activities, and those in which she was at home most of the time. In the latter case, children frequently took care of the baby while the mother was busy with household tasks or out shopping; as a rule this was in the early morning and in the afternoon when they returned from school. In the poorest households women frequently return to income earning activities quite soon after childbirth if there are children between the ages of 6 and 9 to engage in child care. It should be noted that labor markets are highly organized and the working day for women generally lasts from 7 a.m. until about 12 noon, and the time which 6 to 9 year old children spend in child care is usually concentrated in this period. Clearly, this has important implications not only for the low school attendance, but also for the marked inter-monthly variations which exists in school attendance rates. The headmaster of the local school in the village complained about sporadic school attendance and attributed much of it to children being needed at home to take care of younger siblings while both parents were at work.

This evidence supports arguments that even though children's direct contribution to income is small until the age of about 10, they play an extremely important role in releasing adults from routine tasks within the household. Furthermore, the importance of children's activities in the domestic economy is inversely related to the household's physical resource endowments. This bears upon the argument developed by Hart, that the marginal nature of the domestic economy of landless households dictates well co-ordinated inter-dependent time allocation on the part of their members.

Determinants of Seasonal Wage Rates in Village A

While rice production in the village is the main income-earning activity and source of wage employment, there are, as the following figures demonstrate, important alternative income-earning opportunities, particularly for men.

Percentage of Labor Allocated to Sources of Wage-employment, by Sex

	Rice inside village	Rice outside village	Sugar cane	Fish-pond	Tobacco	Other	Total
Women	49.2	16.0	32.8	--	--	2.0	100
Men	28.1	11.4	13.0	32.2	7.1	8.2	100

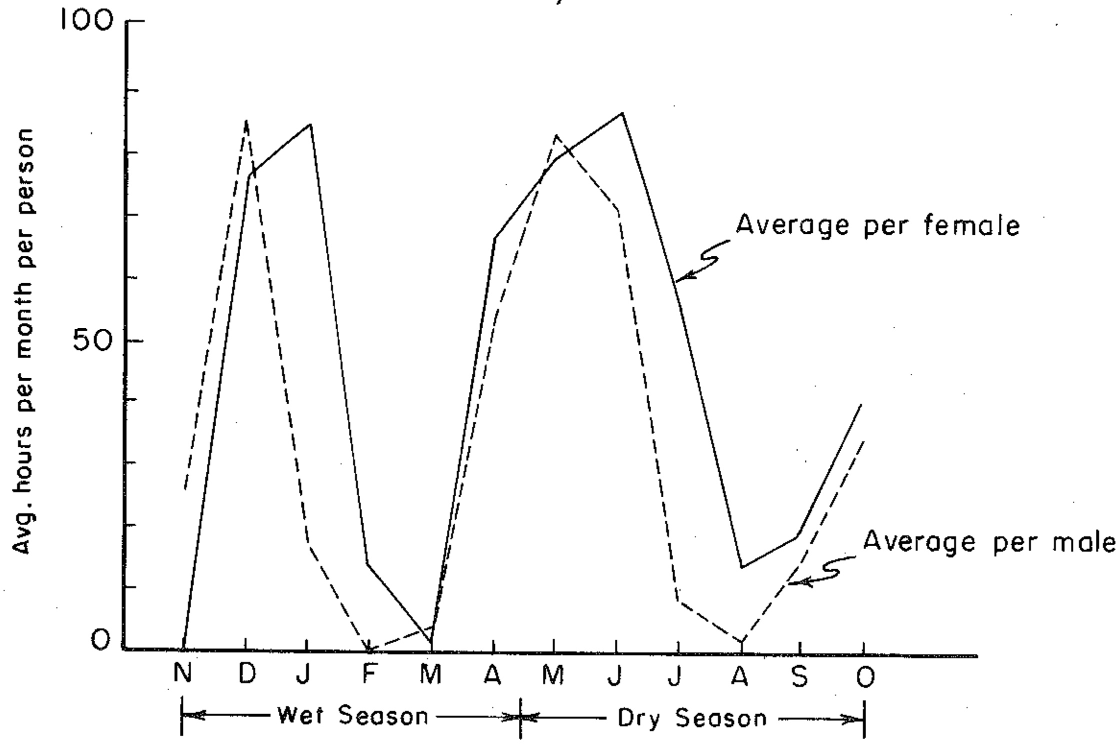
It can be seen that for men, fishpond work is a more important source of wage income than rice production within the village, although when work outside the village is added, rice becomes the major source of wage-employment for men, just as it is for women. Men also have significant opportunities for wage employment in the production of tobacco and also in miscellaneous other jobs. It should be noted that men of all classes have an important self-employment activity--ocean fishing. Reference to table IV.1 indicates that approximately one-sixth of the total income earning time of Class II and III men was spent in this activity. Ocean fishing should be differentiated from fishpond labor, which is a wage-earning activity and is categorized under wage labor in table IV.1. Ocean fishing requires only the most basic equipment and is open to virtually all members of this coastal village. As will be discussed further below, it is, however, an activity which has a significant influence upon the male labor-market at certain times of the year.

For females the only significant alternative source of wages other than rice, is work on sugar cane plantations outside the village. Rice accounts for 65.2 percent of female wage earning time and 39.4 percent for males. Thus, conditions in the market for rice labor dominate the labor market as a whole and give rise to inevitable seasonal patterns as depicted in figures IV.1-IV.3, the main features of which are:

a. The seasonal pattern of rice employment for males and females is much the same in terms of both the level and monthly variation. The wet season peak demand is in December and January, and the slack period in February and March. The dry season peak period is longer and covers May, June, and July, with a slack period in August and September.

b. There are, however, some minor differences (of no more than a month) in the exact timing of the male and female labor demand peaks and troughs. These reflect differences in the allocation

FIGURE IV.1. INTER-MONTHLY VARIATIONS IN RICE EMPLOYMENT WITHIN THE VILLAGE, VILLAGE A, INDONESIA



The Distribution of Rice Labor Activities Among Months[a]

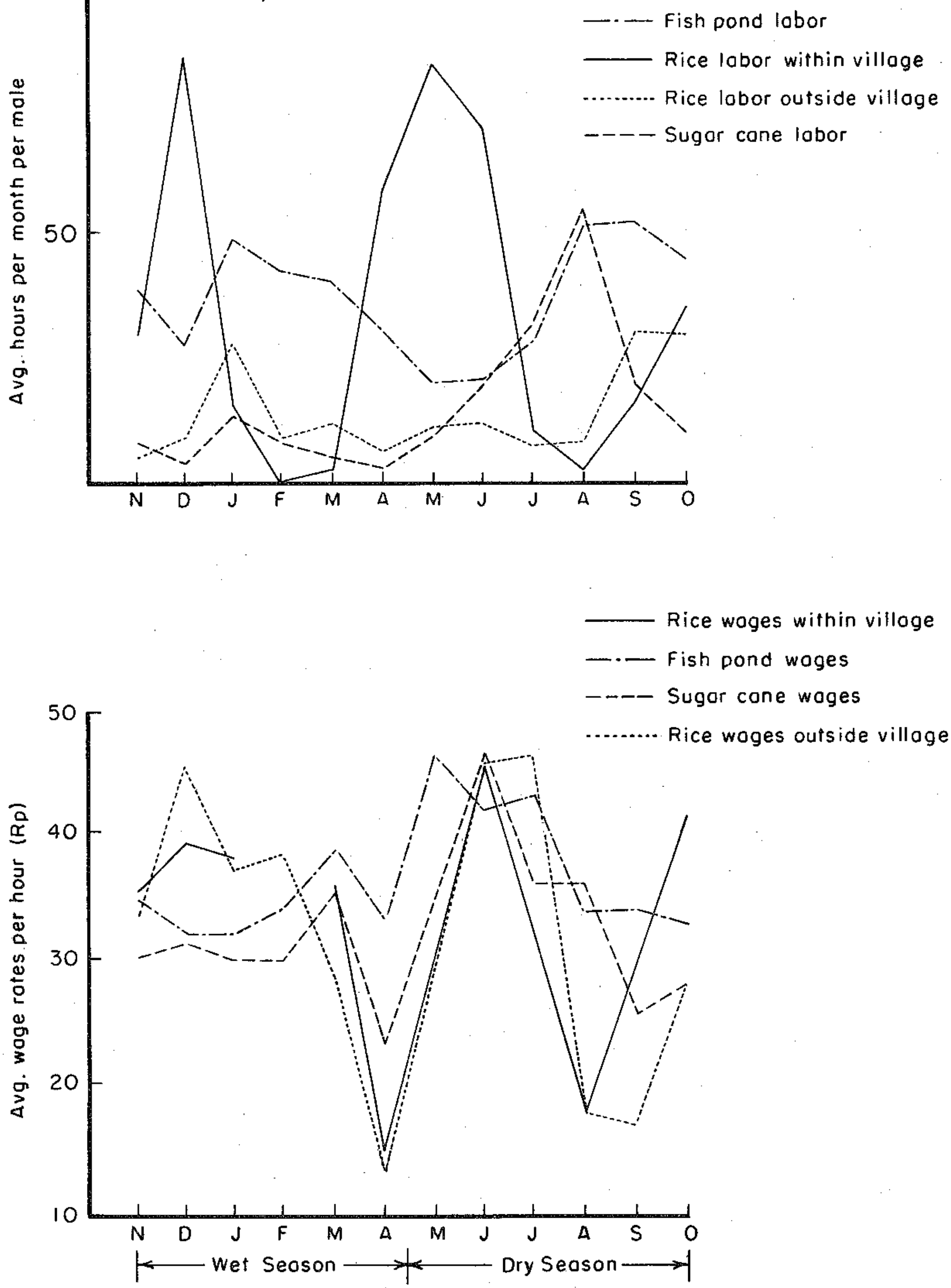
Month	Wet season 1975-76 Female labor	Male labor	Month	Dry season 1976 Female labor	Male labor
Nov.	slack	land prep.[b]	May	harvest	harvest & land prep.
Dec.	transplanting	land prep.	June	transplanting	land prep.
Jan.	weeding	slack	July	weeding	slack
Feb.	slack	slack	Aug.	slack	slack
Mar.	slack	slack	Sept.	harvest (minor)	harvest
April	harvest (major)	harvest	Oct.	harvest	harvest & land prep.

[a]Land preparation includes nursery preparation and care, plowing, hoeing, bunding, barrowing and removing seedlings from the nurseries.

[b]"Month" refers to the month of interview; thus "November" is the period from mid-October to mid-November, and so forth.

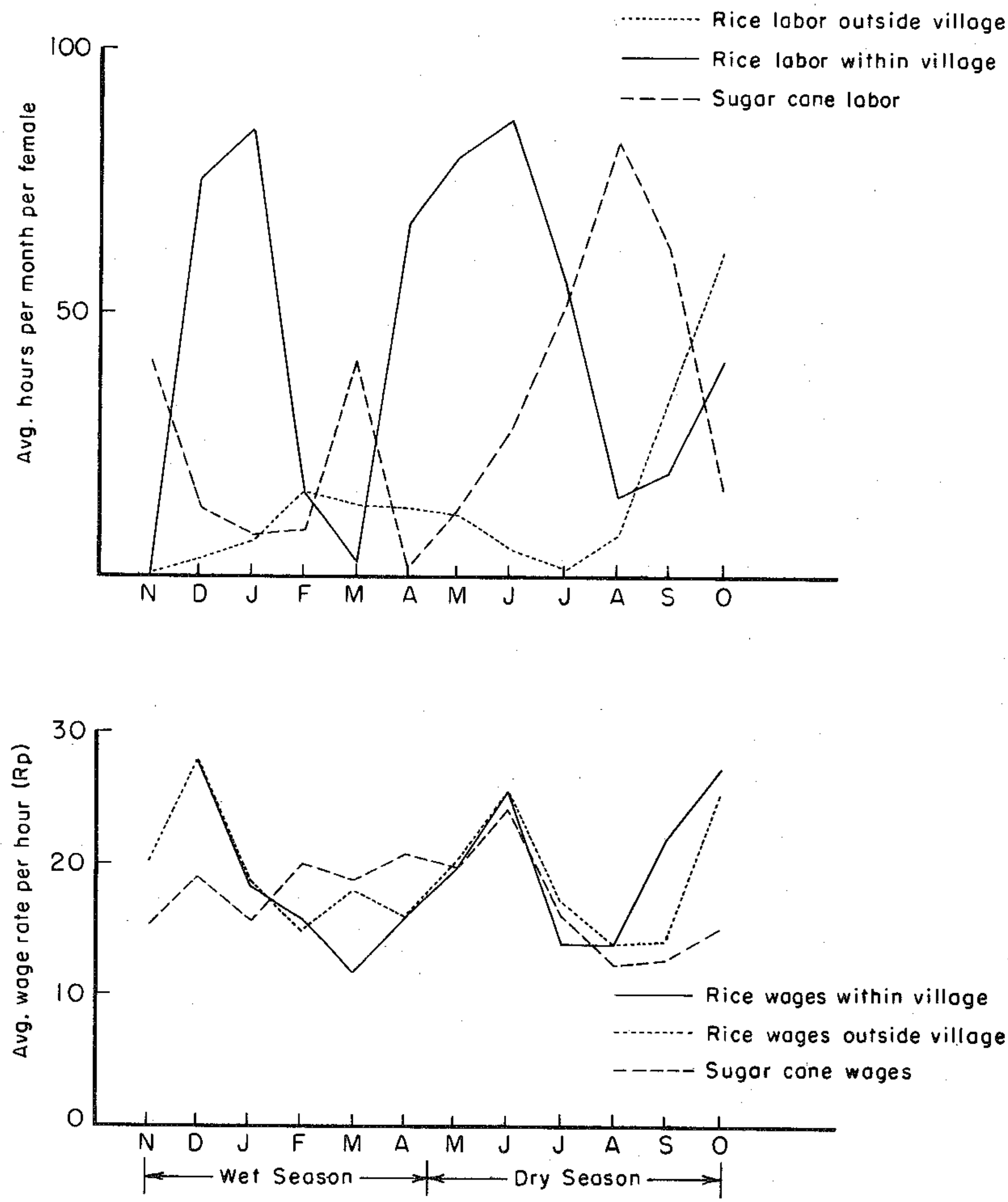
Source: Hart, p. 145.

FIGURE IV.2. MALE EMPLOYMENT AND WAGE RATES IN DIFFERENT LABOR MARKETS, VILLAGE A, INDONESIA



SOURCE: HART, 1978, p. 149

FIGURE IV.3. FEMALE EMPLOYMENT AND WAGE RATES IN DIFFERENT LABOR MARKETS, VILLAGE A, INDONESIA



SOURCE: HART, 1978, p. 147

of tasks by sex. Seedbed preparation and care, land preparation (plowing, hoeing, and harrowing), and the removal of seedlings from the nurseries, are all done by men, as are such tasks as water control, fertilizer, and pesticide application. Transplanting and weeding are regarded as women's tasks, and women also play a major role in harvesting.

c. The seasonal pattern of rice wages (figures IV.2 and IV.3) shows a marked positive correlation with that of employment, although the fluctuations in wages are much larger for males than for females. At the March and August "lows," wages for males and females are about the same, approximately 12 and 16 rupiah per hour, respectively. But at the December and June "highs," hourly wages for males exceed those for females by approximately 10 and 20 rupiah, respectively.

d. The higher male wages at the peak presumably reflect the greater physical demands of the land preparation work performed by males, in comparison to the transplanting work done by females. But the differential is also due in part to the higher opportunity cost of male labor which arises from the existence of alternative sources of income, primarily fishpond labor and to a lesser degree, work in tobacco production. Perhaps even more important is the existence of self-employment opportunities in ocean fishing.

e. The lower degree of diversification among female labor markets is accompanied by greater "competitiveness," which is reflected in relatively low market wage rate differentials and a general tendency for wage rates and the volume of employment to move concurrently. The wage rates for transplanting are approximately twice those for weeding due to the fact that transplanting must be completed in a relatively short time period. In the dry season there were interesting interactions between the sugar cane and rice labor markets which ran counter to this trend. Figure IV.3 shows that sugar cane employment in June was not particularly high; however, the wage rate was the same as that in rice labor in order to bid women workers away from transplanting rice. After June, sugar cane wages followed the decline in rice wages despite the substantial increase in sugar cane employment.

f. In addition to the greater diversity of male labor markets, the relationship among the various markets for male labor are far more complex, and the nature of seasonal changes is different. Figure IV.2 indicates that male wages are less closely linked to the demand for labor in rice production than is the case for women. For example, during the first five months of the wet season (November to March), wage rates were relatively stable despite sharp variations in wage labor employment; instead of accepting lower wage rates during this period and turning to sugar cane labor outside the village, men who could do so switched to self-employment in ocean fishing. During April--the main harvesting period--wage rates in rice labor declined sharply, while employment increased. The reason for this is that only poorer men participate in harvesting, and when they do so they receive wages commensurate with women. In the dry season, with the advent of sugar cane and tobacco cultivation within the village, wage employment opportunities for men increased and became more diverse. This was accompanied by a widening in inter-labor market differentials and an intensification of inter-class disparities in wage rates.

g. It is apparent from figure IV.3 that rice wage labor opportunities within the village were virtually non-existent for females in the slack period of the wet season, and that while some fishpond labor was available for men, this too was limited. Men, women, and children who were prepared to work outside the village could find relatively stable employment in sugar cane fields, and there was some harvesting for cash wages. However, in order to obtain work in the government operated sugar cane fields, workers must establish a formal commercial relationship with the supervisor, and agree to work for a specified period. Wage rates tend to be low, and average returns to labor are further reduced by having to spend two to three hours a day walking to and from work. Those accepting sugar cane work under these conditions are almost exclusively from landless households, and are mainly girls and women; Class II women largely withdrew from the labor market during this period and men turned to ocean fishing.

That landless households, and particularly their female members, had to engage in such a low return activity during the wet season slack period is extremely significant within the context of Hart's main thesis, since it supports the theoretical conclusion drawn from her household time allocation model, that households with no (or few) productive assets will be forced by survival considerations to participate continually in the labor market even if this involves working long hours for very low returns. Hart contends that the need for a stable income will lead members of landless households to prefer the security of the "labor-contract" involved in sugar cane work, despite the low hourly returns.

h. Hart (1978, p. 166) suggests that this security in female earnings was an important factor enabling landless men to attempt high-risk ocean fishing in order to avoid low-paying wage-labor jobs. That ocean fishing is a higher risk activity was demonstrated by the fact that the coefficient of variation for the daily return from ocean fishing was 0.77, as compared to 0.34 for wage labor. The higher average return, however, was evidently sufficient to entice Class III (and Class II) males to devote a significant proportion of their work effort to ocean fishing during the slack period in February and March. Indeed, the average hourly returns in ocean fishing at 50 and 55 rupiah in February and March greatly exceeded the wages for fishpond labor, which were (figure IV.2) 38 and 33 rupiah per hour in

> the same months. As far as can be assessed, during these two months approximately the same amount of male labor time was devoted to each of these activities.

In addition to the seasonality of rice culture which gives rise to important wage rate differentials and time allocation, two institutional arrangements importantly affect the allocation of time and the way in which male-female work patterns evolve. The first is the emergence of a new technique of hiring and rewarding harvest labor; the second pertains to the way in which land ownership may provide preferential access to wage labor.

Tebasan Harvesting. With the adoption of modern varieties of rice throughout Java, a new form of harvesting arrangement--*tebasan*--emerged. It is an arrangement whereby the landlord pays a contractor (*penebas*) to undertake the harvest. The advantages to the landlord are (1) the harvest cost is typically lower, since under *tebasan* a smaller share is taken as payment for harvesting, and (2) the landlord does not have to decide who should be accepted as harvest laborers.

It will be recalled that due to a heavy insect infestation the use of MV was discontinued in Village A the year before Hart conducted her survey. Despite the fact that no MV were used in the study village, the *tebasan* harvesting system has been adopted on land producing local varieties within Village A. Interestingly, *tebasan* harvesting may serve a survival function somewhat analogous to the contract sugar plantation work engaged in by women, since the middleman hires harvest labor to work for a specified period, usually for several days. This means that even though the rate of harvest pay may be somewhat lower, the members of Class III households have additional assurance of labor instead of waiting each dawn for possible selection as a part of the harvest crew, as is the case under traditional harvesting. Furthermore, Hart argues that there are strong indications that a group of household members working together may earn higher average return per person than individual laborers. The middleman may offer an entire household, both women and men, employment in the harvest. This can serve to bring more male labor into harvesting and provide an alternate survival strategy. It is true and while it may involve lowered average returns to adult men, women and children receive higher average returns. Thus in October--the period when tebasan harvesting was most prevalent--inter-class wage differentials for women narrowed considerably, whereas those for men remained large.

This combination of females in low-risk, low-return jobs and males in high-risk, high-return jobs is interpreted as a method by which Class III households seek to maximize joint family incomes. Hart's analysis clearly points out the tremendous contribution of women in the survival strategy of landless households. Were it not for the stability of daily income to meet minimal food requirements provided by female labor, men could not participate in the more lucrative ocean fishing which increases aggregate annual income. In striking contrast, ownership of even very small amounts of land allows home production of rice which provides a subsistence minimum, thereby making it unnecessary for the women of Class II households to participate in low wage contract labor.

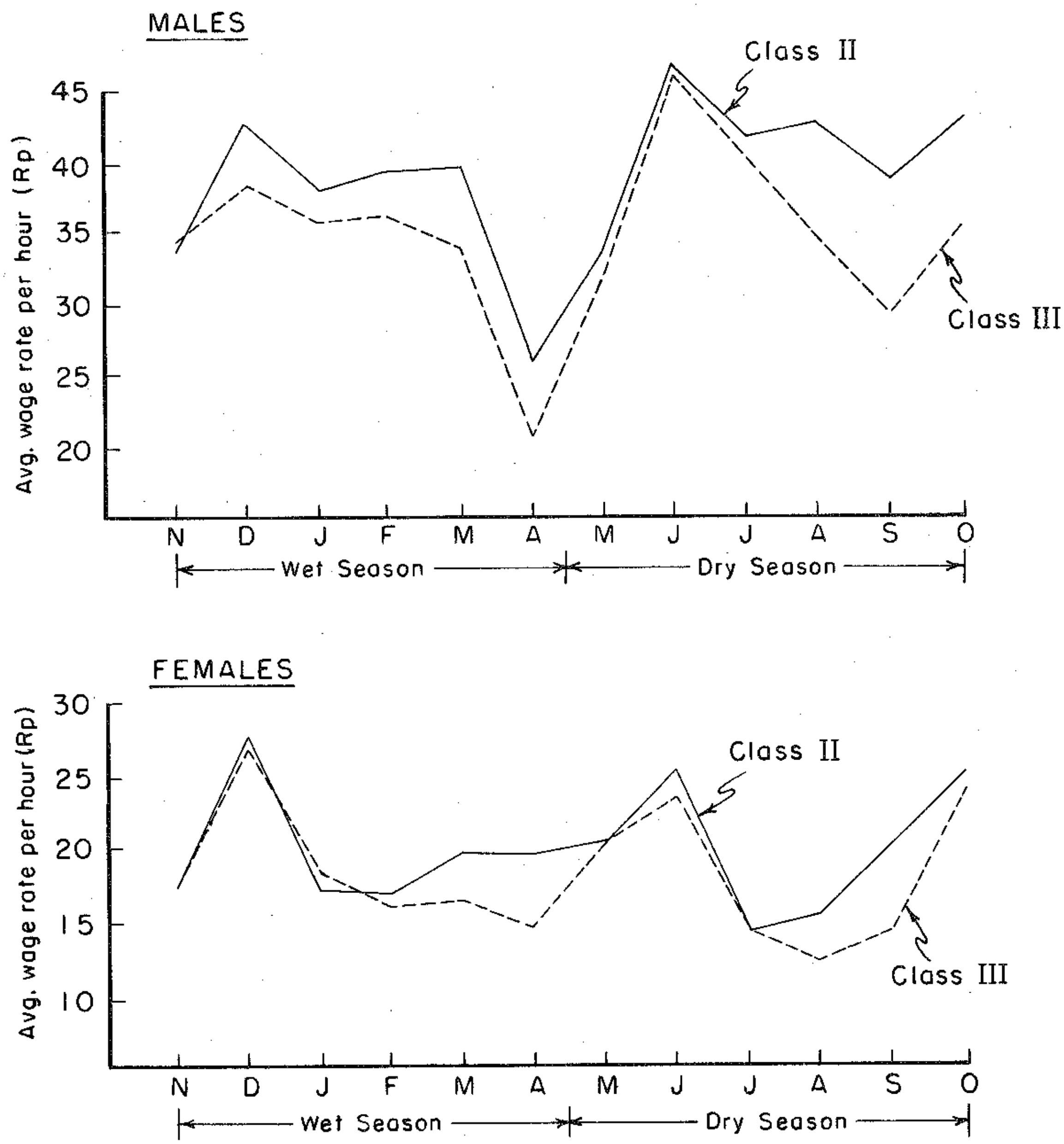
Labor Access and Shared Poverty. Geertz undertook his pioneering analysis of inter-class differences and the concept of "shared poverty" and labor access on Java over a decade ago. Village A was selected specifically to examine the aspects of shared poverty and agricultural involution discussed by Geertz (1963). Class differences in household work patterns are not solely the direct product of asset ownership and household preferences; they also appear to be influenced indirectly by asset ownership. This is to say, as Hart argues, that there are restrictions (or preferences) on access to jobs which depend upon class (asset ownership). The ways in which these restrictions operate are not easy to identify directly or in detail, but are inherent in the methods of labor recruitment. Hart (1978, p. 97) records that virtually all the recruitment and organization of transplanting labor is carried out by a small group of women from the class of medium landowners.

In the case of land preparation and weeding there is more direct contact between employers and laborers, although some of the largest landowners delegate some recruitment to one or two of their sharecroppers or tenants (known as buruh dekat or "close laborers"), with whom they have what appears to classic patron-client ties. Particularly in the case of male labor activities, which tend to extend into relatively slack periods of labor demand, worker-employer relationships are very important in determining access to these more limited employment opportunities; such jobs are comparatively attractive since they are within the village. The nature of inter-household relationships is also extremely important in determining access to traditional (bawon) harvesting, in which the harvester receives a share of the crop.

Hart argues that the combined effect of all these forms of patronage is for large landowners to give preferential job access to members of small landowning (Class II) households, and that one way in which this becomes manifest is in the payment of higher wage rates to members of Class II households than to those in Class III. Inspection of figure IV.4 provides support for this hypothesis. Wage rates for Class III males are seen to have been below those for Class II males at all times during the year; while for females, Class III wages were markedly below those for Class II in the two slack seasons, at which times the existence of class-based barriers to entry to the work force assumes a critical dimension for the poorest families. Multiple regression analysis lends support to these hypotheses by demonstrating that there were statistically significant positive relationships between the value of a household's productive assets (a continuous class variable) and the earnings of its male and female members in precisely those months for which figure IV.4 indicates a relatively large wage rate difference. For males, assets were found to significantly affect earnings in all months other than November, January, and March; for females, this relationship was significant in January, March, April, May, August, and September (Hart, 1978, pp. 151-162).

The data collected by Hart in Indonesia have permitted an interesting and unusual insight into differences in economic behavior and opportunities between rural families with different capital endowments. Particularly, it has generated empirical information about how these vary as families change position on a scale descending from comparative affluence to continuous poverty. One of the most significant conclusions is that instead of a set of institutions to share work with the poorest, what exists is a highly competitive labor market into which are built

FIGURE IV. 4. DIFFERENCES BETWEEN WAGE RATES OF SMALL-LANDOWNING (CLASS II) AND LANDLESS (CLASS III) HOUSEHOLD MEMBERS, IN VILLAGE A, INDONESIA



SOURCE: HART, 1978, pp. 160, 161

some features which actively discriminate against landless households. The other main conclusion is that within this system the poorest households adopt time-allocation and work strategies which attempt to maximize security of work and income, and involve such integration of the activities of members of the households, that joint household income is maximized subject to security (risk) considerations. It was further demonstrated that a lower level of household ownership of productive assets was associated with a higher working time per household member, and a much greater level of income earning work by girls and adult females.

A careful examination of the relationship between wage rates and hours worked reveals that labor markets operate with a substantial degree of sensitivity to seasonal variations in demand and work opportunities. From an economic standpoint the findings also show that wage rates are very close to the marginal value product of female and male labor in rice production. These findings strongly suggest that Geertz's notions of work spreading and shared poverty are incorrect. It appears that differential access to employment opportunities, which are based on land ownership, are a much stronger force in determining who will obtain work in rice production, than any feeling of paternalism or a communal attitude of shared poverty.

Tractor Mechanization and Family Labor Allocation
on Farms in Chittoor District, India

The available data for Chittoor District restricted Doraswamy's analysis of household time allocation to inter-farm differences in the proportions of farm labor supplied by the operator's household and by hired labor. It thus differed in important ways from Hart's analysis of the Indonesian village in that (1) it did not encompass any landless or near-landless households; (2) it only considered on-farm work, so that there was no way of knowing whether an observed reduction of on-farm labor by the operator's family was associated with a reduction in its total labor commitment or with a switch to other work; and (3) it did not record the time spent by operators in supervisory work. To the extent that this changed systematically with particular household or farm characteristics, the impact of these upon the proportion of family labor may have been over or (less probably) underestimated.

Before considering the statistical results relating to time allocation, it is worth noting Doraswamy's hypothesis that a marked increase in school enrollment by the younger members of farming households reduces the amount of family time available for on-farm work, thereby stimulating the adoption of tractors as a substitute. This hypothesis is heightened in significance by Hart's arguments concerning the interdependent labor roles of household members, and in particular, by her observation that the availability of children for household chores and child care releases adults for income earning work.

There are two ways in which increased school enrollment causes reduced family labor availability. First, it removes children from direct participation in farm jobs, and second, but more importantly, there is the indirect effect that children are no longer available for child care and housework, and this causes women to be withdrawn from farm labor to assume these tasks. The reasons to suppose that increased school enrollment has been a factor causing the adoption of tractors in Chittoor District are twofold. First, in Chittoor the number of children attending school rose from 177,000 in 1958/9 to 277,000 in 1974/5; this was a much faster rate of increase than that of the child population as a whole. Second, there is some evidence (see table IV.4) that proportionately more children are enrolled in school on the tractor-owning farms. This shows up only in the 16-24 age group for males, the level of school attendance being uniformly high for both males and females in the 5-15 age group. It can be seen from table IV.4 that in the 16-24 group, only 11 out of 35 males on non-tractor owning farms were students, whereas on tractor-owning farms the proportion was much higher, 13 out of 20. Although this is hardly conclusive support for the notion that increased child education has resulted in significant pressure for tractorization, the hypothesis is a plausible one.

Turning now to the statistical analysis of the determinants of inter-farm differences in the proportions of farm labor performed by the operator's family and by hired labor, the method used was binomial logit analysis (multinomial logit scaled to handle two alternatives), in which the regression results to explain the proportion of family labor infer exactly

TABLE IV.4.--Age and Sex Composition of Family Members by Occupation on Tractor-owning and Non-tractor-owning Farms, Chittoor District, India

	Number of Males						Number of Females					
	Below 5	5 to 15	16 to 24	25-65	Above 65	Total	Below 5	5 to 15	16 to 24	25-65	Above 65	Total
Non-tractor-owing farms												
Students	0	39	11	0	0	50	0	48	2	0	0	50
Workers in non-agriculture	0	0	1	9	0	10	0	0	0	1	0	1
Workers in agriculture	0	2	16	73	0	91	0	0	0	8	0	8
Non-workers	27	0	7	26	3	63	19	8	29	96	4	156
Total	27	41	35	108	3	214	19	56	31	105	4	215
Tractor-owning farms												
Students	0	28	13	0	0	41	0	19	2	0	0	21
Workers in non-agriculture	0	0	0	0	0	0	0	0	0	0	0	0
Workers in agriculture	0	0	5	36	0	41	0	0	0	0	0	0
Non-workers	13	1	2	28	3	47	15	3	17	52	5	92
Total	13	29	20	64	3	129	15	22	19	52	5	113

Source: Doraswamy (1979).

offsetting results for the proportion of hired labor. The analysis was conducted separately for the major farm labor activities at each of the four centers. The explanatory variables employed were (1) the total work to be performed per potential family worker (R), (2) per capita income per annum, (3) years of formal education of the head of the household, (4) a dummy variable for tractor hire, and (5) a dummy variable for tractor ownership--each of the two tractor variables were included as interacting slope shifters, as well as intercept shifters. All of these variables are self-explanatory except for R, which is redefined for each separate labor activity. For example, for plowing, R is the total hours of plowing labor used (required) on the holding divided by the number of family members (potential workers) between the ages of 16 and 63. Thus, the value of R increases with increases in cropped acreage and with the labor intensity of the crops grown, and decreases with the number of potential workers.

The statistical analysis produced statistically significant coefficients for nearly all variables in each of the equations estimated. Because of the interaction terms, the coefficients could not be interpreted singly and directly, and the effects of the major variables were traced out by simulation analysis. The results obtained are (subject to the qualifications noted above) roughly consistent with Hart's, assuming that income, education, and tractor ownership are positively associated with class as defined by Hart. In fact, the most clear-cut results are obtained for the effects of income, as shown in table IV.5. For nearly all classes of farms and centers--three farm classes times four centers produce 12 simulations

TABLE IV.5.--Differences in Labor Allocation and Farm Characteristics, by Mechanization Class of Farm, Chittoor District, India

	Non-tractor using farms (CI)				Tractor-hiring farms (CII)				Tractor-owning farms (CIII)			
	Labor Supplied (hrs/year)			% Labor Supplied	Labor Supplied (hrs/year)			% Labor Supplied	Labor Supplied (hrs/year)			% Labor Supplied
Operation	Family	Hired	Total	by Family	Family	Hired	Total	by Family	Family	Hired	Total	by Family
Plowing	164	237	401	41	58	236	294	20	67	86	153	43
Planting	151	914	1,065	14	103	1,453	1,456	7	71	3,126	3,197	2
Maintenance	682	1,160	1,842	37	872	2,114	2,986	41	920	4,384	5,304	21
Harvesting	222	1,901	2,123	10	237	2,686	2,923	8	224	5,277	5,501	4
Crop Production	1,219	4,211	5,430	22	1,271	6,488	7,759	16	1,282	12,872	14,154	9
Non-crop Production[a]	1,325	1,412	2,736	48	971	1,448	2,420	40	667	2,544	3,211	21
Total	2,544	5,623	8,166	31	2,242	7,936	10,179	22	1,949	15,416	17,365	11

Farm Characteristic	CI	CII	CIII
Assets ('000 Rs)	133	179	366
Acreage	7.8	7.9	17.9
Annual Income ('000 Rs)	11.1	15.5	32.3
No. Family Members	6.8	5.5	8.6
Potential Ag Workers per family	4.2	3.5	5.5
Years of Schooling of Household Head	5.2	7.1	7.8

Source: Doraswamy (1979).

[a]This category consists of other on-farm labor activities, the largest constituent of which involves livestock.

for each labor activity--income was estimated to have a negative influence on labor participation by the operator's family for plowing and harvesting, and in the majority of cases for planting and crop maintenance. It is notable that all the cases of positive relationships between income and the proportion of family labor occurred for Pedda Kannali and Aragonda, although there is no ready explanation why this should be so.

In the case of the education variable (number of year's schooling of the household head), the results obtained were neither dramatic nor clear. In general, it can be said that in nearly all cases (four centers times four labor operations) higher education was associated with lower family labor input on non-tractor using farms. But for tractor-hiring and tractor-owning farms there was a nearly equal number of positive and negative relationships. Again, there was no ready explanation for these contradictions. Overall, however, it appeared that, as with higher income, the dominant effect of more education was to reduce the commitment of operator family labor to on-farm work. If the results were not wholly convincing, despite the statistical significance of the estimated coefficients, it was probably due, in part, to some multicollinearity between the explanatory variables, and to the fact that there were insufficient observations to support the more complex analysis necessary for complete testing.

An observation on the way in which education bears on the adoption of technology may be in order. In this case the researcher was not working with secondary data or with information collected from an extremely large sample. The age, sex, labor, and education patterns of all family members sampled were known. Traditional wisdom indicates there should be a positive relationship between education and the adoption of agricultural technology such as tractor mechanization. The researcher feels that when the head of the household is 30-60 years of age, the level of education obtained 20-50 years earlier may not be an important explanatory variable relative to current behavioral patterns. Clearly, literacy is important, however, there may be very little distinction between four years of education and eight in terms of the impact of education on decisions to purchase a tractor or install an irrigation system. Many more important factors may have intervened in the period from the termination of education to the time of decision making.

One additional observation may be made. Clearly, tractor owning families are more affluent than non-tractor owning families. From the standpoint of family labor allocation, this is manifested by the fact that approximately 5 percent of the males on non-tractor owning farms have sought non-farm jobs, while no male members of households owning tractors work off the farm.

SUMMARY AND CONCLUSIONS

Technological Change in Rice Production in Asia

The widely held conception of changing rice technology in Asia is that of the "Green Revolution," which is associated with the introduction of higher yielding semi-dwarf rice varieties. These modern varieties (MV) were first released for commercial production by the International Rice Research Institute (IRRI) in 1965/6, and have since been widely adopted throughout Asia. The complementary adoption of MV and inorganic fertilizers, plus improved water control, constitute the central aspects of technological change in rice farming. The benefits of the adoption of these technologies accrue in two ways: First, they provide for significantly higher yields per crop. But in many areas it is of equal or even greater importance that they have permitted multiple cropping--an increase in the number of successive crops grown per hectare--in some cases as many as five crops in two years. To achieve high levels of cropping intensity, improved water management is essential, but the availability of faster maturing modern varieties also plays an important role, as does the adoption of improved systems of transplanting seedlings.

Second, there have also been significant changes in the adoption of other modern inputs, such as tractors, mechanical threshers, pumpsets, herbicides, and insecticides. Since these inputs often substitute for traditional factors such as animal power--but most importantly, labor--their adoption gives rise to especially significant policy issues relating to the distribution of output between labor and other factors of production. It is clear that the reasons for adopting these other technologies are not to be found solely in the technical and economic conditions brought about by the introduction of MV. The data in table 1 indicate that there was a significant level of adoption of some "modern" technologies prior to the introduction of MV. Seventy-five percent of the sampled Indonesian farmers, 62 percent of those in Pakistan, and a sizable number of those in the other study areas had employed inorganic fertilizer prior to 1966. Tractors were relatively common in Pakistan and the Philippines before 1966, and mechanical threshers and herbicides were employed on more than 30 percent of Philippine farms; insecticides were widely used in all the areas except Malaysia and Pakistan. Evidence that technologies other than fertilizer, and possibly insecticide, are not necessarily complementary with MV is provided by the fact that in several of the countries shown in table 1, their use was negligible or significantly lower than the rate of adoption of MV.

Using the IRRI data in table 2, it is interesting to observe the influence of farm size on the technology adopted. As can be seen, there is comparatively little difference between the three size classes in their rate of adoption of the complementary technologies--MV, fertilizer, and insecticide. In fact, the largest farms appear to have a marginally lower rate of adoption of these technologies than the smallest farms. In con-

TABLE 1--Cumulative Proportion (%) of Farmers Who had Used Modern Technology in 31 Villages in Selected Areas of Asia, by Technology Type, by Country

	1900–1960	1961–1966	1967	1968	1969	1970	1971	1972	Percentage Using in 1972
Modern Varieties of Rice[f]									
India	0	0[d]	27	43	77	93	96	96	()[c]
Indonesia	0	0	28	64	83	88	90	90	()[c]
Malaysia[a]	0	0[e]	--	--	--	--	100	100	()[c]
Pakistan	0	0	0	11	21	38	100	100	()[c]
Philippines	0	0	36	71	91	99	100	100	()[c]
Thailand	0	0	0	0	0	41	92	82	()[c]
Fertilizer[a]									
India	6	41	60	70	91	97	98	100	99 (100)[b]
Indonesia	32	75	81	94	99	99	99	99	99 (96)
Pakistan	27	62	65	72	79	80	81	81	76 ()[c]
Philippines	15	33	51	67	77	80	83	84	72 (76)
Thailand	2	20	27	38	50	61	76	82	69 (82)
Tractors									
India	0	9	11	13	20	22	27	27	26
Indonesia	0	0	1	3	5	14	15	15	2
Malaysia[a]	--	--	--	--	--	--	--	96	96
Pakistan	3	46	57	67	72	73	73	73	73
Philippines	10	24	37	46	57	61	61	61	58
Thailand	0	5	6	9	15	22	33	33	25
Mechanical Threshers[a]									
India	0	7	8	9	9	9	9	9	9
Indonesia	0	0	0	0	0	0	0	0	0
Pakistan	0	0	0	0	0	0	0	0	0
Philippines	19	27	38	50	62	65	65	66	63
Thailand	1	6	11	27	38	45	55	55	44
Insecticide									
India	3	31	48	63	80	89	91	91	88
Indonesia	31	68	74	92	93	96	96	96	92
Malaysia[a]	--	--	--	--	--	--	--	45	45
Pakistan	4	9	9	25	42	55	58	58	58
Philippines	16	43	59	75	89	95	97	97	97
Thailand	5	32	39	42	50	56	76	76	71
Herbicide									
India	--	1	1	2	2	2	2	2	0
Indonesia	--	0	0	0	0	0	0	0	0
Malaysia[a]	--	--	--	--	--	--	--	8	6
Pakistan	--	0	0	0	0	0	0	0	0
Philippines	--	32	45	51	67	71	72	76	65
Thailand	--	4	6	6	7	10	10	10	8

Source: IRRI (1978a), pp. 16, 99, 100.

Notes: [a]Data missing for Malaysia for all or part of the period.
[b]The figures in parentheses are for the dry season, the others for the wet season.
[c]Not available.
[d]Modern rice varieties were introduced in India in 1965/6.
[e]Modern rice varieties were introduced in Malaysia in 1965.
[f]The data on adoption of modern rice varieties is for 32 villages. Data for Zarain in India was omitted in calculating the other statistics.

TABLE 2--Cumulative Rate of Adoption of Some Improved Rice Culture Practices by Farmers in Selected Areas in Asia, 1971/72

Practice, farm size	1900-1960	1961-1966	1967	1968	1969	1970	1971	1972
	Cumulative rate (%) of adoption							
				MV				
1 ha or less	0	13	35	69	85	89	93	93
1.1 to 3.0	0	9	27	56	89	98	99	99
over 3 ha	0	7	19	34	49	68	92	92
				Fertilizer				
1 ha or less	23	55	73	92	96	97	98	98
1.1 to 3.0	10	34	48	64	78	83	86	88
over 3 ha	14	50	61	73	81	86	90	91
				Insecticide				
1 ha or less	23	49	64	84	89	92	93	93
1.1 to 3.0	12	39	53	67	87	94	95	95
over 3 ha	6	32	45	52	62	70	83	83
				Herbicide				
1 ha or less	0	0	0	0	0	0	0	0
1.1 to 3.0	6	13	16	21	29	31	32	32
over 3 ha	3	27	39	48	56	63	71	71
				Tractor				
1 ha or less	0	18	19	20	21	25	25	25
1.1 to 3.0	6	13	16	21	29	31	32	32
over 3 ha	3	27	39	48	56	63	71	71
				Mechanical thresher				
1 ha or less	0	0	1	1	1	1	1	1
1.1 to 3.0	8	12	15	22	31	32	33	33
over 3 ha	9	21	30	35	39	41	44	44

Source: IRRI (1978a), p. 91.

trast, the largest farms show a markedly higher rate of adoption of mechanical technology (tractors and threshers) and herbicides. This confirms that these particular inputs are not indispensable complements to MV, fertilizer, and irrigation, and being substitutes for labor, they have no significant place in the production systems of labor-abundant small farms.

Further justification of this last assertion is provided by the results of Hart's (1978) Indonesian study. The land farmed by all farm-size classes in the study village was virtually homogeneous in quality, yet Hart's data, presented in table 3, indicate that the smallest farms apply 76 percent more labor per hectare than the largest farms, and obtain approximately 60 percent higher yields. This is consistent with the results from other Asian sites, which show that small farmers apply their abundant labor intensively in order to maximize output per hectare, and are receptive to technology which permits them to achieve higher yields in this manner.

TABLE 3--Labor Input[a] and Yields by Farm Size in Rice Production Preharvest Activities, Village A, Central Java, Indonesia (Wet Season in 1975-76)

		A >1.0	B .50-.99	C .30-.49	D .19-.29	E <.19
Average area (hectares)		3.147	0.676	0.377	0.271	0.118
Absolute labor input (hours)						
Female:	Family	40	45	54	87	65
	Hired	1209	211	109	72	27
	Total	1249	256	163	159	92
Male:	Family	1277	88	135	119	68
	Hired	1335	210	84	49	17
	Total	1462	298	219	168	85
Total absolute labor input		2711	554	382	327	177
Labor input per hectare (hours)						
Female:	Family	20	66	143	354	455
	Hired	360	306	306	266	233
	Total	380	372	449	620	688
Male:	Family	70	133	383	456	619
	Hired	374	296	223	180	147
	Total	444	429	606	636	766
Total labor input per hectare		824	801	1055	1256	1454
Yield per hectare (tons of wet paddy)		1.965	2.318	2.220	2.546	3.123
No. of observations		6	13	13	11	17

Source: Hart (1978), p. 143.

[a]A female labor day (transplanting and weeding) is between four and five hours, whereas the average male labor day is seven hours. Labor data exclude supervisory work and travelling time. They also exclude activities such as protecting the crop from birds in the period before the harvest, and preparing food for laborers.

Constraints to the Adoption of New Technology

Yields achieved on experiment station test plots are considerably higher than those realized in farmers' fields. It may be unrealistic to express test plot performance as a target; however, it is important to consider factors which bear on the gap between what is technically feasible and farm level performance. Quantification of components of the yield gap, and ascertaining a target which farmers might realistically be expected to reach, is extremely difficult.

While it is easy to understand the frustration of national planners attempting to increase rice production, it seems that expectations are frequently pitched too high. Most research to date has concentrated on improving rice technology for areas with good water control, while less progress has been made for lowland rainfed, upland, or deep water rice. Thus, only in those countries where irrigated rice land represents a substantial proportion of the total rice-growing area can large increases in yield and input use be expected.

Even in the well-irrigated areas to which the new technology is adapted, it appears that there may be a serious danger of over-estimating potential. This is suggested by the results of an interesting research program conducted by IRRI in South and Southeast Asian countries (IRRI, 1975; Herdt, 1976). This research was conducted in irrigated areas where all farmers employed MV, where rice was the main, or only crop, and where husbandry practices could be considered progressive. The research was carried out in farmers' fields, and was designed (1) to test the contributions to yields attributable to the use of fertilizer, insecticide, and weed control; (2) to estimate the economic optimum use of these inputs; and (3) through surveys accompanying the field experiments, to determine the reasons why farmers' use of inputs was below the economic optimum. It was found that high input applications on farmers' fields led to lower yields than those of experiment stations, due to differences in environment and to elements of nontransferability of the technology.

There were significant differences depending on the season. In the wet season, only comparatively modest increases could be made by increasing the levels of the three inputs, the average potential yield gain being 0.9 metric tons per hectare, with a range from 0.1 to 2.0 (see table 4). In the dry season, larger potential yield gains were possible, with an average of 1.5 metric tons per hectare and a range of 0.4 to 2.2 (table 5). It should be noted that due to a peculiarity in the definitions used, the maximum attainable dry season yields at several centers were significantly higher than the "potential" levels. Nevertheless, these maximum yields are less dramatic than experiment station results might suggest were possible. A most significant finding is that at many study sites it would have been uneconomic for farmers to have increased input application to the level required to realize maximum yields. This is shown clearly in table 6, which indicates that the returns maximizing input levels were generally lower than those required to maximize yield per hectare. In the wet season it appears that use of inputs was not markedly below the economic optimum. Farmers used inputs at an economically rational level, rather than striving for

TABLE 4--Measured Potential Rice Yield[a], Actual Yield, Yield Gap[b] and Contribution of Three Types of Inputs in Experiments on Farmers' Fields, Wet Seasons, Selected Asian Sites, 1974-75

Location	Year	Trials (no.)	Yield (t/ha) Farmers'	Yield (t/ha) Potential	Yield (t/ha) Gap	Contribution (t/ha) of Fertilizer	Contribution (t/ha) of Weed control	Contribution (t/ha) of Insect control	Contribution (t/ha) of Residual
Philippines									
Nueva Ecija	1974	10	1.9	2.3	0.4	-0.1	0.2	0.4	-0.1
Indonesia									
Subang	1975	4	2.2	2.4	0.2	0.1	-0.1	1.3	-0.1
Bangladesh									
Joydebpur	1976[c]	9	2.7	2.8	0.1	0.1	-0.1	0.1	0
Sri Lanka									
Giritale	1975/76	4	2.9	4.0	1.1	0.2	0.2	0.8	-0.1
Philippines									
Nueva Ecija	1975	11	3.2	3.9	0.7	0.3	0.1	0.2	0.1
Laguna	1974	10	3.6	5.6	2.0	1.1	0.3	0.8	-0.2
Laguna	1975	20	3.6	5.3	1.7	0.7	0.3	0.7	9
Camarines Sur	1975	6	3.6	4.6	1.0	0.4	0.1	0.6	-0.1
Thailand									
Supan Buri	1974	3	3.7	5.1	1.4	0.7	0.3	0.3	0.1
Supan Buri	1975	7	3.9	4.6	0.7	0.5	0.1	0.2	-0.1
Indonesia									
Yogyakarta	1974/75	3	4.2	4.7	0.5	0.7	-0.1	-0.1	0
Taiwan									
Taichung	1975	3	5.6	6.6	1.0	0.5	0.2	0.1	0.2

Source: Herdt (1976), table 4.

[a]The high input packages which produced the potential yields were not in all cases the highest input packages which could have been applied with positive marginal yield. Thus potential in this case is not strictly equivalent to maximum attainable yield.

[b]This refers to yield gap II.

[c]Aus season.

TABLE 5--Measured Potential Rice Yield[a], Actual Yield, Yield Gap[b] and Contribution of Three Types of Inputs in Experiments on Farmers' Fields, Dry Season, Selected Asian Sites, 1975-76

Location	Year	Trials (no.)	Yield (t/ha)			Contribution (t/ha) of			
			Farmers'	Potential	Gap	Fertilizer	Weed control	Insect control	Residual
Indonesia									
Yogyakarta	1975	2	2.6	3.9	1.3	1.0	0.4	-0.3	-0.4
Subang	1976	3	3.1	3.5	0.4	0.3	0.1	0	0
Bangladesh									
Joydebpur	1975/76[c]	6	3.5	5.2	1.7	1.3	0.4	na	0
Philippines									
Camarines Sur	1976	8	3.3	4.8	1.5	1.3	0.1	0.2	-0.1
Camarines Sur	1975	3	3.9	5.6	1.7	1.1	0.1	0.4	0.1
Thailand									
Supan Buri	1975	7	4.1	6.3	2.2	1.5	0.5	0.3	-0.1
Philippines									
Nueva Ecija	1976	8	4.2	6.2	2.0	1.3	0.3	0.6	-0.2
Nueva Ecija	1975	3	4.3	5.2	0.9	0.2	0.5	0.2	0
Laguna	1976	12	4.4	6.1	1.7	1.0	0.2	0.6	-0.1
Laguna	1975	9	5.6	7.4	1.8	1.3	0.2	1.0	0.1
Taiwan									
Taichung	1976	3	6.2	7.0	0.8	0.5	0.2	0.1	0

Source: Herdt (1976), table 5.

[a]The high input packages which produced the potential yields were not in all cases the highest input packages which could have been applied with positive marginal yield. Thus potential in this case is not strictly equivalent to maximum attainable yield.

[b]This refers to yield gap II.

[c]Boro Season

TABLE 6--Increased Profit and Rice Yield of Alternative Input Management Packages Compared to Farmers' Practices, from Experiments on Farmers' Fields, Selected Asian Sites, 1974-76

Location	Year	Trials (no.)	Increased net return per hectare over farmers practices					Increased yield (t/ha)	
			Units	M2[a]	M3	M4	M5	at max. net return[b]	at max. yield
					Wet seasons				
Philippines									
Nueva Ecija	1974	10	Peso	31	-358	-902	-2053	0.2	0.7
Nueva Ecija	1975	11	Peso	205	146	-178	-256	0.2	1.2
Laguna	1975	5	Peso	-841	-1751	-1262	-1056	0	1.3
Camarines Sur	1975	6	Peso	381	658	-158	-846	1.1	1.1
Thailand									
Supan Buri	1974	3	Bhat	336	836	-540	-2281	0.9	1.4
Supan Buri	1975	6	Bhat	-422	-1023	-3034	-4316	0	0.4
Indonesia									
Yogyakarta	1974	3	Rupiah	-14000	11330	-1660	10660	0.5	1.0
Sri Lanka									
Giritale	1975	4	Rupees	1528	1399	829	855	0.5	1.2
					Dry seasons				
Philippines									
Nueva Ecija	1975	3	Peso	-486	-522	280	357	2.1	2.1
Nueva Ecija	1976	9	Peso	a	820	1748	1864	2.3	2.3
Laguna	1975	9	Peso	-690	-666	-65	-768	0	1.5
Laguna	1976	7	Peso	a	1045	1296	2153	2.1	2.1
Camarines Sur	1975	3	Peso	-536	177	307	-181	1.5	2.0
Camarines Sur	1976	5	Peso	a	283	221	561	1.8	1.8
Thailand									
Supan Buri	1975	7	Bhat	365	488	-1167	-1455	1.1	2.2
Indonesia									
Yogyakarta	1975	2	Rupiah	22000	51000	80000	157000	2.7	2.7

Source: Herdt (1976), table 6.

[a]M2, M3, M4 and M5 are increasingly higher combinations of input management packages.

[b]Note that for the dry season at the majority of centers the economic optimum yield increase exceeds the yield gap shown in table III.11. At several centers this may partly reflect a change in sample size, but in general is due to the point raised in footnote (a) in tables III.10 and III.11.

maximum yields through high levels of input use. In the dry season the highest input levels were economically justified in 5 of the 8 areas studied.

It should be recognized that the rice acreage in the dry season is appreciably smaller than that in the wet season, and that increases in dry season yields will have only a comparatively small effect on annual average rice yields. It is estimated that for the period 1970-75, only 7.4 percent of the rice acreage of all Asian countries was double cropped in the dry season. (Of an estimated total rice area of 78.3 million hectares, only approximately 5.8 million were double cropped with rice.)

It should be observed that though the potential for increased yields is greatest for the dry season, it is still comparatively small. This is shown in table 7, in which the second crop can be taken as being equivalent to the dry season irrigated acreage. On this basis it can be estimated that for the 11 countries listed, the dry season irrigated acreage amounted to only 22 percent of the wet season irrigated acreage, and to only 7.4 percent of the total wet season acreage. The same data also show clearly that the optimal habitat for MV--irrigated land--comprises only 34 percent of the rice-growing area in the wet season. The dominant land category is rainfed, which accounts for 51 percent of the wet season area. It is clear, therefore, that further research to develop superior technology for growing rainfed rice is likely to contribute significantly to lifting constraints to the further adoption of modern inputs in rice production.

The dominant reasons for the low level of input adoption revealed by the IRRI study were poor water control, lack of knowledge, infrequent

TABLE 7--Estimates of the Proportion of Rice Area in Five Major Environmental Categories, 11 Asian Countries, 1970-75

Country	Total rice area ('000 ha)[a]	Proportion of area (%)				
		Irrigated	Rainfed	Upland	Deep-water	Second crop
India	37,755	40	50	5	5	5
Bangladesh	9,766	16	39	19	26	10
Indonesia	8,482	47	31	17	5	19
Thailand	7,037	11	80	2	7	2
Burma	4,985	17	81	1	1	1
Philippines	3,488	41	48	11	0	14
Vietnam[b]	2,713	15	60	5	20	5
Pakistan	1,518	100	0	0	0	0
Nepal	1,200	16	76	9	0	0
Malaysia (W)	771	77	20	3	0	50
Sri Lanka	604	61	37	2	0	25

Source: Herdt (1976), table 1.

[a]1970-74 average area, FAO data.

[b]Former South Vietnam.

extension contact, difficulties in obtaining credit, and problems of obtaining inputs on time. It is important to note that these constraints are largely outside the control of farmers and do not imply inefficiency or ineptitude on their part. It is, however, within the realm of policy to expand credit facilities, increase extension services, and improve the input supply system, although the IRRI research suggests that the returns to such policy developments may be modest.

Though the IRRI research did not explore constraints to the adoption of MV, this aspect was examined by Pachico (1979), in a study of the middle hills of Nepal. Pachico's research concentrated on the factors determining the proportion of the wet season lowland rice acreage allocated to each of three rice varieties--Taichin, a nitrogen-responsive dwarf variety; Pokhareli, a comparatively high yielding Nepalese variety; and Thapachinia, formerly the most commonly grown local variety. Of these, Taichin is the highest yielding, though it is more difficult and time-consuming to thresh than the lower yielding Pokhareli. Taichin's slightly shorter growing season also makes it an attractive variety, offsetting the fact that it has somewhat poorer taste and cooking qualities. Pokhareli requires more transplanting labor than Taichin, and the Pokhareli plants are frequently bound together before harvest to prevent lodging. This practice amplifies labor requirements before and during the harvest period. The seasonal labor requirement profiles of the two main varieties are therefore distinctly different. Thapachinia, the local variety, has markedly lower yields than Pokhareli, but it also has a much shorter growing season and excellent cooking qualities. As a consequence of the interaction of these varietal differences, a place exists for each of the varieties within the system, although Taichin is dominant. The complexity of the interactions can be illustrated with three points: (1) the higher yielding Taichin is preferred by small farmers operating close to subsistence, but with adequate family labor to cover the harvest peak; (2) larger farmers, who must hire labor, react to the cost and difficulty of obtaining harvest labor by growing a relatively high proportion of Pokhareli, which has a lower harvest labor requirement than Taichin; and (3) larger farmers combine a higher proportion of Thapachinia with the other two varieties because its early maturation spreads the harvest labor peak, and it supplies fresh rice at an earlier date for festivals. These findings give an indication of the constraints that exist to the introduction of a new variety, such as Taichin, into an existing farming system. Such a system operates within certain patterns of labor availability and food needs, which dictate the use of a combination of varieties rather than one single variety, and so represent constraints to the complete adoption of any new high yielding varieties.

It has already been noted that the economically optimum level of input use is sometimes lower than might have been expected, and that economic considerations impede the adoption of technology. However, the economic optimum is a function of the price of rice, the prices of inputs, and the cost of credit. In many cases these are largely determined by agricultural and industrial pricing policy, and as has been reported, these prices do appear to be discernably related to the levels of adoption of the new technology. Thus, the economic constraints to adoption perceived by farmers are to a large extent determined by policymakers, and are outside the control of farmers.

The Hart (1978) and Ranade (1977) studies used production function analysis to examine economic and technical efficiency in the use of factors of production. Their findings are of greatest interest relative to the use of labor. Hart found that with respect to labor, larger farms tend to operate at a point which is sub-optimal in terms of profit maximization. Her empirical results cast doubt on the presumption that very small farms tend to be inefficient and suggest, in fact, the opposite. The analysis also indicated that the marginal value product of rice labor in this Indonesian village is far from zero. In the case of activities performed by males, increasing labor inputs per hectare did not decrease the marginal value product of labor, whereas it did produce significantly higher yields.

In the Philippines, Ranade found that farmers using traditional technology operated at the optimum level for labor use, given their supply of land. It was concluded that laborers were not paid less than their marginal product on either traditional or mechanized farms. The analysis showed that modern technology was both land and labor-saving. The land-saving bias substantially outweighed the labor-saving bias. In both areas, production function analysis bore out the conclusion that farmers were rational in their use of labor in combination with available land and other inputs.

The Effects of Technology on Income, Employment, and Factor Returns

Clearly the new rice technology should not be examined as if it were an indivisible whole, but rather the separate components of that technology must be studied. With survey data, it generally proves too difficult to disentangle the separate effects of new varieties, fertilizers, tractors, pumpsets, etc., and some compromise is necessary. Such compromises were certainly adopted by Ranade (1977) and Doraswamy (1979) in their studies of the impact of technological change in the Philippines and India. In Ranade's study of Laguna and Central Luzon, the combined effect of the adopted package of technology on employment, and the revenue accruing to the various factors of production, as well as the different socioeconomic classes, was examined. In addition, there was extensive analysis of the effects of tractors and mechanical threshers, plus some partial results for the effects of irrigation and the use of chemicals (including fertilizers, insecticides, and herbicides).

In Doraswamy's study of Chittoor District, India, attention was focused principally upon the effects of mechanization in the form of tractors on employment, output, and cropping patterns. Doraswamy's study is especially interesting in this latter regard, for unlike the studies by IRRI, and those by Ranade (1977) and Hart (1978), which took place in areas where rice was virtually the sole crop, the Chittoor District study examined a situation where rice was only one of a number of major crops (the other being sugar cane, groundnut, and other grains), thus permitting analysis of the effect of tractors upon cropping patterns and intensity.

Ranade's results for the Philippines confirmed that in irrigated areas, farmers adopting MV and fertilizers can expect marked increases in yield and higher net returns. In fact, over the study period it appears that the adoption of these inputs increased average yields by up to 50 percent, and benefited all participants: landlords, tenants and landless laborers. It was determined that there were positive returns to the factors of production themselves, i.e., it was economically rational to use fertilizer, insecticides, and herbicides. The distribution of the additional output between the different factors and the different participants was by no means equal. This, however, was due in part to a highly effective land reform scheme carried through in the Philippines, which disadvantaged landlords and favored operators.

In the Philippines it was expected that MV, fertilizer, and irrigation would have significant output-increasing effects; this is entirely consistent with other survey results, including those published by IRRI. Ranade's findings with respect to the impact of mechanization can be summarized as follows:

--There is no evidence to suggest that the use of tractors or mechanical threshers has a positive effect on rice yields.

--Tractors in the Philippine study were not employed in activities other than land preparation, and they substituted for labor, mainly from the operator's family, in this task. The reduction of labor demand for this task on tractor using farms tended to be more than offset by increased demand for labor (mainly hired) in planting, weeding, and harvesting. None of these latter effects can, however, be attributed to the use of tractors. The first two were probably due to improved husbandry practices such as the adoption of straight-line planting and row-by-row weeding; and since there was no evidence that tractor using farms had higher yields, the reason for the latter effect is unclear.

--Since hired labor constituted a high proportion of harvesting and threshing labor, the employment effect of threshers fell mainly on hired labor. This contrasts with the effects of tractors, and suggests that the effects of threshers upon income distribution are socially much less attractive than those of tractors.

--In Central Luzon, the shares of operators and operators' residuals were appreciably higher on farms employing tractors than on non-mechanized farms.

--The use of threshers was associated with operators' shares and operators' residuals even higher than those on farms using tractors only. This suggests the existence of a strong private incentive for the adoption of threshers in Central Luzon, against which the social cost of job displacement must be set in perspective.

--As a result of changes in the labor task composition due to mechanization, average wage rates were lower on tractor using farms than on non-mechanized farms, and even lower on farms employing mechanical threshers. From the standpoint of the welfare of hired laborers, this is a most interesting finding which does not appear to have been considered in other studies.

Doraswamy's results for the impact of tractor use in Chittoor District, India are very much in the same vein as for the Philippines. Again, tractor use in crop production was found to be almost exclusively confined to the plowing operation. Hence the only crop operation in which tractor use was found to significantly affect (reduce) labor demand was plowing, and since plowing labor constituted an average of only 5 percent of labor demand, the effect on the total labor required for any particular crop was small. The possibility therefore, was that the main effect of tractor use on labor demand might be to change the composition of crops produced and to increase the proportion of those requiring more labor.

An interesting analytical technique was conducted to test this hypothesis, with the expectation that if the use of tractors for plowing showed any effects on cropping patterns it would be for one of two reasons: (1) Because of its effect on timeliness, it might permit expansion of the acreage of crops with a short plowing to sowing interval--primarily paddy on wet land and groundnut on dry land, and permit expansion of crops which are highly specific with respect to planting date--this applies chiefly to groundnut on wet land. (2) Because it reduces labor and bullock requirements for plowing, it might permit expansion of the acreage of paddy, which has an especially high demand for plowing time. A third effect might also have been expected: the possibility that acreage used to produce forage for draft animals would be freed for the production of other crops. This was not the case, since in the study site draft animals are fed largely on grain stubble, and there is, therefore, little forage acreage to displace. It was anticipated that any crop effects of mechanization would show up largely in increased paddy and groundnut acreages. This in fact was what the statistical analysis showed, but the effects were undramatic and in several cases not significant.

The main results of this analysis can be summarized as follows:

--In general, the net effect of tractorization on plowing labor demand was negative; the change to crops requiring more plowing labor was outweighed by the displacement of labor in the plowing operation.

--The main crop effect associated with tractorization on labor demand was found in all non-plowing operations, and this was positive in most cases. The largest of these effects was found to be on tractor hiring (as opposed to owning) farms. The increase was 28 percent on farms owning tractors and 70 percent on farms hiring tractors.

--One of the notable features of the results was that from the point of view of increasing hired labor demand, the hire of tractors was more favorable than ownership, since farms hiring tractors used them more sparingly than owning farms. Consequently, in most cases it was found that ownership of tractors decreased total labor demand more than tractor hiring.

--If the four Indian sites are aggregated, it appears that tractor hiring was associated with some increase in total (plowing and non-plowing) labor, but the effect was not marked. No such conclusion is possible for tractor ownership.

--In view of the difficulty which is usually encountered in separating the employment effects of tractorization from (the independent) yield effects, it is worth noting that Doraswamy's procedure successfully differentiated the separate effects.

The results obtained by Ranade (1977) and Doraswamy (1979) confirm that tractors are not necessary for increased rice output in the areas studied. They also fit into the pattern of results presented by Binswanger (1978) in his recent review of over one hundred studies of the effects of tractors in South Asia. He concluded that:

> The tractor surveys fail to provide evidence that tractors are responsible for substantial increases in intensity, yields, timeliness, and gross returns on farms in India, Pakistan and Nepal. At best, such benefits may exist but are so small that they cannot be detected and statistically supported. . . . Indeed the fairly consistent view emerging from the surveys largely supports the view that tractors are substitutes for labor and bullock power, and thus implies that, at existing and constant wages and bullock costs, tractors fail to be a strong engine of growth. They would gain such a role only under rapidly rising prices of those factors of production which they have the potential to replace. (Binswanger, 1978, p. 73)

The results could be interpreted as indicating that tractor mechanization is neutral in a rice-based economy; however, this conclusion must be tempered by two additional considerations. First, at present the use of tractors appears to be primarily confined to plowing. It can only be assumed that in order to make better use of tractors, the range of activities in which they are employed must increase, with a resultant increase in labor displacement. Second, although adoption of tractors may not appear to reduce the demand for hired labor in the areas studied, the supply of hired labor has increased rapidly as a consequence of population growth. Thus, to the extent that tractor use has retarded growth in labor demand it has important social implications.

The Economic Condition and Behavior of Different Socioeconomic Classes

The distributional impact of technological change upon different socioeconomic classes is conditioned by (1) any scale biases in that technology; (2) any biases in the institutions involved in the factor and product markets; and (3) by differences in the economic behavior and reactions of the different socioeconomic classes. This latter topic has been the object of an in-depth study by Hart (1978) in Indonesia, with complementary findings emerging from the other studies. The research findings provide a valuable background for any consideration of distributional issues relating to rice technology. Hart's study illuminates the marked differences in the capacities of the different classes to advance themselves, by demonstrating the relative lack of dependence of the richer members of the rural community upon the poorer. Hart's analysis indicates that social and technical changes are weakening the dependency between classes.

Three classes of households were identified in the Indonesian village. These classes were based on ownership of land sufficient to generate various levels of income. The poverty level is defined as income equivalent to the value of 300 kg milled rice per consumer unit, and subsistence as an income equal to 150 kg milled rice per consumer unit--the quantity necessary to meet basic staple food requirements. Class I households were those with adequate land to produce income equivalent to or greater than 300 kg per consumer unit. Class II households were those with sufficient assets to enable production in excess of the staple food requirement of 150 kg milled rice per consumer, while Class III households were those controlling insufficient assets to meet even staple food needs. The percentages of households in each of these classes were approximately 24, 33, and 43 percent, respectively. Given that the principal productive asset determining asset status was agricultural land controlled, it is evident that the largest class, Class III, consisted essentially of landless families who had to find wage employment, or some role in the informal sector to attain even subsistence levels of consumption. While a further third of households operated small amounts of land and generated sufficient own-production to cover subsistence needs, they also needed to find employment in order to achieve the poverty standard of consumption.

Hart observed major inter-class differences in employment patterns, and the nature and extent of these differences is particularly interesting. In terms of hours worked, class differences were found to have the least effect upon men, for whom only a small direct relationship was noted between hours worked and class. Naturally, however, the nature of adult male employment differed greatly with asset status, with men from Class I spending 87 percent of their time working with their own assets, while men from Class III spent 91 percent of their income earning time in wage employment (see table 8).

However, in terms of income earning contribution, the main impact of class was revealed in the economic role of women and children whose contribution increased substantially as asset status declined. Indeed, in the poorest families there was surprisingly little difference on average, be-

TABLE 8--Average Hours Worked per Year at Different Job Types, by Class, Sex, and Age, Village A, Central Java, Indonesia

Class		Hours per Household	Hours by Females	Hours by Males	Average Hours per Person				
					Persons 9 yrs	Girls 10 - 15	Women 16	Boys 10 - 15	Men 16
Own Production[b]	1	3,813	321	3,492	1,048	44	242	508	2,246
	2	1,567	240	1,327	431	44	183	432	839
	3	299	59	240	92	17	46	178	141
Trading[b]	1	615	462	153	171	0	369	0	108
	2	448	418	30	122	43	325	36	1
	3	237	170	67	75	5	132	14	56
Wage Labor[b]	1	552	222	330	153	54	158	52	209
	2	2,798	996	1,802	771	416	641	304	1,291
	3	4,164	1,984	2,180	1,290	1,168	1,202	554	1,706
Gathering[b]	1	65	45	20	19	23	28	22	5
	2	341	224	117	94	172	97	97	45
	3	467	277	191	147	169	162	124	120
Ocean Fishing[b]	1	29	-	29	9	-	-	32	9
	2	582	-	582	160	-	-	421	265
	3	536	-	536	169	-	-	461	290
All Income Earning Activities[b]	1	5,074	1,050	4,024	1,400	121	797	614	2,577
	2	5,736	1,878	3,858	1,578	675	1,246	1,290	2,441
	3	5,703	2,499	3,214	1,773	1,359	1,542	1,331	2,313
Housework[a]	1	1,812	1,666	145	499	362	1,216	31	90
	2	1,589	1,443	146	437	438	1,003	57	82
	3	1,254	1,173	80	390	392	800	37	61
All Activities[b]	1	6,886	2,716	4,169	1,899	483	2,013	645	2,667
	2	7,325	3,321	4,004	2,015	1,113	2,249	1,347	2,523
	3	6,957	3,672	3,294	2,163	1,751	2,342	1,368	2,374
Travel to and from Work	1	713	126	587	nc	nc	nc	nc	nc
	2	723	229	494	nc	nc	nc	nc	nc
	3	690	291	399	nc	nc	nc	nc	nc

Source: Hart (1978), pp. 124, 126, 128.

[a]Hours per male < 10.
[b]Including travelling time.
nc: not calculated.

tween the total working hours of any type of family member over nine years of age. Boys in Class III were recorded as averaging 1,368 hours of work per year, girls 1,751 hours, women 2,342 hours, and men 2,374 hours. This contrasts with the comparable figures for the richer Class I households of 645, 483, 2,013, and 2,667 hours, respectively. Thus women and children in families with little land were forced to participate extensively in income earning activities. It is important to add that despite their efforts, the average Class III household only achieved an average income of 274 kg milled rice equivalent per consumer, which was below the 300 kg poverty level. Moreover, because of their need to find a relatively sure source of income, members of poor families (particularly women and children) exhibited a tendency to accept low wages in return for some security of employment. These and related findings assume particular significance within the context of Hart's study, since they support the main conclusion of her theoretical model that households with no or few productive assets will be forced by survival considerations to participate continually in the labor market, even if this involves working long hours for very low returns. It is also significant that it was women, elderly males, and children who provided this anchor role for the household economy leaving men, who had a wider range of income earning opportunities, to participate in higher return employment. In striking contrast, ownership of even very small amounts of land allowed household production of rice at a subsistence minimum, thereby making it unnecessary for women of Class II households to participate in low-wage contract labor.

There is a further noteworthy economic dimension to the extensive participation by the 10 to 15 year-olds in Class III households in the labor market; this is that it restricts their attendance at school, thereby limiting any opportunities to escape from their poor circumstances through education. Thus, they are effectively caught in a low-income trap. This is reinforced when it is noted that Hart observed that even children below 10 years of age played an indirect but important role in the economy of the poorest households. In the poorest households, children between the ages of 6 and 9 were responsible for looking after younger siblings in order to free mothers for paid employment.

The overriding impression presented by Hart's study is of family members forming in an integrated work team, with individuals adopting roles which permit the family, as a unit, to maximize income and security of work. Furthermore, the observations support the theoretical hypothesis that this behavior is dictated by poverty, and that the degree of coordination within families declines as their productive asset base increases.

It is also worth noting that the conclusion regarding the economic role of women and children within the family is also supported from an entirely different standpoint by a hypothesis proposed by Doraswamy (1979), in his study of mechanization in Chittoor District, India. The situation there is essentially one of a much higher level of affluence than that found in Indonesia, and is one in which educational levels are higher. Based on cross-farm analysis, Doraswamy hypothesizes that increased school enrollment may cause increased mechanization on farms by reducing family labor availability. It does this by removing children from direct participation in farm work, but more importantly it necessitates the withdrawal of women's labor from the farm in order to take over the child care formerly performed by older children.

Class differences in household work patterns are not solely the direct product of asset ownership and household preferences; they can also be influenced indirectly by asset ownership. This is to say, as Hart (1978) argues for the Indonesian case, that there are restrictions (or preferences) on access to jobs which depend upon class (asset ownership). Hart identified a number of mechanisms for the distribution of patronage in assigning available work. The overriding effect of these was that the small land-operating households in Class II had an advantage over the landless Class III households in gaining access to the employment offered by large landowners. One result of this was the systematic tendency of wage rates paid to Class II members to exceed those for Class III. The existence of these biases calls into serious question the notion that in traditional rural systems, institutions exist to share work with the poorest. Instead, what exists is a highly competitive labor market into which are built mechanisms which actively discriminate against landless households.

The Influence of Technological Change on the Labor Market and Other Institutions

It has been observed that the distributional consequences of technological change are, in part, a function of institutional arrangements in the factor markets. This is especially true of labor markets, and it is therefore important that significant changes were observed in the arrangements for hiring and paying harvesting labor in Indonesia and the Philippines. Harvesting labor is the main source of wage employment for landless laborers.

A major change which has been observed in both countries is the moving away from the traditional situation where anyone who wished to participate in a farmer's harvest could do so in return for a pre-determined share of the harvest, to one in which there is restriction on who is permitted to undertake harvest work. In addition, the changes serve to restrict the share of the harvest which is paid for harvesting labor. More specifically, in Indonesia a change has been observed from the traditional bawon system, in which harvesting was open to all, towards closed bawon systems, in which only certain people can participate, and more significantly to the tebasan system, in which the landlord pays a contractor to organize the harvest. These changes have been accompanied by a reduction in the share of the harvest paid out to labor, although to the extent that yields have increased this does not necessarily signify that total payment to harvest labor has declined. In the Philippines (among other changes) there has been a movement away from the system in which all could participate in the harvest in return for a sixth share, to a system in which workers must provide free weeding labor during the growing season in order to participate in the harvest and receive the one-sixth share.

Although these institutional changes cannot be wholly attributed to the introduction of new rice technology, it seems entirely reasonable to argue that it has provided a significant stimulus for them. Given that the higher yields obtained with the new varieties are not primarily attributable to harvesting labor, there is an obvious rationale for reducing the share of production distributed to such labor. The changes noted in Indonesia and the Philippines have provided an effective means of accomplishing this. Of course the other major incentive for these changes has been the growth in the number of landless people and those with inadequate productive resources of their own. This has swelled the supply of harvesting labor to the point where some mechanism, other than price, for rationing available work has become necessary in certain places.

It is debated by Hayami and Hajid (1978) whether these institutional changes, caused in part by changing rice technology, can be interpreted as being biased against the landless and other poor. It is certainly conceivable that if the price of harvesting labor were allowed to find (fall to) its equilibrium level, total returns to labor might be lower than in the emerging labor rationing systems. Nevertheless, these institutional changes do represent some breakdown of the paternalistic ethic which has often been assumed to operate in rural communities. They discriminate against potential poor job seekers, and they represent a significant element of the process whereby economic change excludes poorer people from its benefits.

The raising of this issue of marginalization through institutional change, and through the way in which economic institutions and relations operate, indicates a shortcoming in the work summarized here. In the studies reported, no results have been obtained regarding possible impacts of the new technology upon the size distribution and number of holdings, or upon the pattern of control over land and wealth in general. Rather, the inquiry has been from the opposite end, how the adoption of technology is influenced by these factors. That there is an expanding literature (especially for areas of Asia, where mechanical technology has been introduced) which suggests that the new technology intensifies forces leading to concentration of land ownership/control, and to increasing inequality in incomes. The main reasons for such tendencies are thought to be attributable to the large farm biases in factor markets, and this is particularly true of credit used for the purchase of tubewells, tractors, pumps, fertilizer, etc. If such tendencies are inherent in the new rice technology, as authors such as Griffin (1974) argue that they inevitably are, then any adverse distributional consequences noted for the new technology in this summary would be increased.

It would be anticipated that the higher yields resulting from adoption of the seed-fertilizer technology would be accompanied by increased labor demand. It is here that the difficulties of disentangling this effect from the labor demand effects of other technological changes presents problems. While the Cornell research does not address this issue directly, evidence from other sources does indicate that adoption of MV and higher fertilizer use increases labor demand, but this increase is proportionately smaller than the increase in yields, so that labor input per ton of rice declines.

Policy Implications

The research conducted by Cornell provides support for the prevailing view that the new rice technology has had a significant positive impact on rice yields, output, and to a lesser extent, employment in South and Southeast Asian countries. It is also apparent that there is further progress to be made, since the use of modern varieties (MV) and associated inputs could be increased in many countries. This is particularly true, since use of the associated inputs (fertilizer, insecticide, and improved weed control) are apparently being used below economically optimum levels. Care must be taken not to exaggerate the potential for further development with the current MV and technology. The main thrust of plant breeding research to date has been directed to rice varieties with high fertilizer response on irrigated land, while less research has been directed at increasing potential yields for rainfed, upland, and deepwater rice varieties. The potential yields of MV are appreciably higher for the dry season irrigated rice crop than for the wet season crop. It should be noted that the dry season irrigated rice acreage is relatively small compared to wet season irrigated acreage (see table 7). Furthermore, it was found (table 6) that in the wet season, farmers who grew MV were applying associated inputs at levels far closer to the economic optimum than might have been expected. In part, this is because the economically optimum application of inputs from the farmers' points of view was less than the level required to maximize yields per hectare. In the dry season, it was found that the extent to which farmers were using input levels below the economic optimum was more marked. The principal restrictions on this acreage are (1) that in the colder northern latitudes in Asia the dry season is too cold and has too short a growing season for rice, so that any second irrigated crop must be hardier than rice (e.g., wheat); and (2) that water supplies are inadequate to provide irrigation for significant portions of the area during the dry season. To lift these restrictions calls for further research to develop cold resistant varieties, and also for more investment in irrigation, where this can be economically justified.

The research also indicates that farmers in Asia have been highly receptive to the new seed-fertilizer technology, have reacted rapidly, and are very capable of perceiving what is to their economic advantage. Evidence of this has emerged in a number of ways. First, adoption of inorganic fertilizer and other new inputs had been quite extensive in some areas prior to the drive to introduce MV. Adoption of MV has proceeded rapidly since their introduction in 1966, and there has been a rapid further increase in the use of other modern inputs. It is also notable that the smallest farmers appear to have been the most avid adopters of the seed-fertilizer technology, applying their abundant family labor to these and traditional inputs at higher levels than larger farmers, and obtaining higher yields. Indeed, the evidence supports the position that breaking up larger holdings will result in increased production. Certainly the land reform carried out in the Philippines appears to have been successful in the study areas and to have had no adverse impact on production.

It is particularly relevant for policy that the constraints causing farmers to underemploy resources were found to be largely outside their control, but susceptible to policy action. In some cases, significant numbers of farmers were found to be ignorant of the economic possibilities of the new technology. While from one standpoint this could be interpreted as a reflection on the drive and initiative of farmers, from another, it reflects weaknesses in the institutions which disseminate technical and economic information. Many farmers were aware, however, that higher returns could be expected from employing more inputs. Risk (an uncontrollable factor) was one reason given as inhibiting higher input use, but from the policy standpoint it is more significant that the cost and availability of credit, and the physical non-availability of inputs at times when they were wanted appear to have been major constraints to higher input use. There are economically rational reasons for not fully adopting the modern rice varieties. Such reasons were identified by Pachico (1979) in Nepal, and help to explain the rationale for continuing to plant some of the rice acreage to traditional local varieties. These reasons suggest that expectations about the potential penetration of MV should be tempered.

At an even higher level of policy, it should be observed that the economic returns from adopting technology are directly influenced by political intervention in factor and product markets. It is not uncommon to observe government agencies exhorting farmers to greater efforts, while pursuing pricing policies which restrict the economic returns to such efforts. This observation is particularly significant in that technically feasible rice yields are held up as targets, but they may exceed the economic optimum. Changing policy-determined prices will change the economic optimum production levels of farmers.

It should be emphasized that the modern technology being applied to rice production is not an indivisible set of complementary inputs. It is true that there is a very high degree of complementarity between irrigation facilities, MV, and inorganic fertilizers. In certain localities insecticides, and less frequently, mechanization may be highly productive. From a social welfare standpoint, the most questionable inputs are tractors and mechanical threshers, which only appear to be crucial complements in special situations. Tractors are being increasingly adopted in most rice growing areas, and mechanical threshers are also being used in a few countries. The evidence, however, suggests that in most of the areas where mechanization has occurred its impact on yields is negligible, but more critically mechanization has had no detectable influence on the potential for double cropping in rice production. The social benefits from mechanization thus appear to be rather small, in general, although they may be high in special circumstances.

The private benefits of mechanization are evidently high. This appears to be especially true of threshers in the Philippines, where their labor-saving effect was observed to be large. In contrast, the labor-saving effect of tractors was found to be quite modest and to be confined almost entirely to land preparation activities, which account for a small proportion of total labor demand. This contrasts with the impact of tractors in wheat-growing areas of Asia, in which larger four-wheeled tractors are being used for a wide range of cultural tasks. In the few areas of

South and Southeast Asia which still have relatively favorable land-labor ratios, the divergence of private and social returns to these mechanical technologies may be small at this stage, but in more densely populated areas the divergence may be large, and be exacerbated by policies of cheap credit and subsidies on inputs. In such areas, the spread of mechanical technology should be geared to the size of social returns and policy should be directed to reducing the gap between these and private returns.

This last observation raises the issue of the distribution of the benefits of the new technology; that is, of how the returns are distributed between different socioeconomic groups. This is of particular significance against the background of increasing rural landlessness in large parts of Asia and the fact that while the economies of virtually all Asian nations are growing, the absolute number of people living in abject poverty is expanding. Thus, critical issues for policy are whether additional employment for hired laborers, and particularly landless laborers, is created, and also of whether the new technology sets up forces leading to further concentration of land control and increasing landlessness.

Regrettably, no complete answer to these questions is possible, but there are a number of partial indicators which are suggestive. Cornell research conducted in the Philippines (Ranade, 1977) concluded that all relevant socioeconomic groups (landlords, operators, hired labor, and input suppliers) have gained where the seed-fertilizer package has been adopted, although the size of these gains has been affected by the land reform program which restricts the extent to which the results can be generalized. What is clear, however, is that the seed-fertilizer technology has resulted in higher yields, and in an associated increase in total labor demand, although labor requirements have increased at a slower rate than yields. Hired labor demand, however, has been observed to increase at a faster rate than that for total labor, since there appears to be a discernable tendency for families operating larger land areas to decrease the amount of family labor performed by sending their children to school, by reducing female labor input, and by diverting some male labor to other activities. Nevertheless, the rate of increase in hired labor demand remains less than the increase in yields.

Hart's (1978) study in Indonesia has provided evidence that the landless do not benefit from the increase in labor demand to the same degree as small farm operators, and that large land operators exhibit a bias in favor of those owning land in their hiring policy. This suggests important implications relating to policy decisions which promote rural employment through public works projects, such as construction of roads, dams, or educational facilities. Few rural people view public works employment as permanent or reliable. Consequently, the "survival strategy" of the landless would probably induce them to maintain established work patterns. In contrast, self sufficiency in rice production places small landowning households in a stronger position to accept the risk associated with this employment. Even if the landless are willing to disregard job uncertainty, there is reason to suppose that unequal work opportunities would operate against them. It therefore appears that public works projects would be only marginally successful in providing increased employment for the landless.

When tractors are employed in conjunction with the seed-fertilizer technology, the increase in labor demand is moderated somewhat. Where threshers are employed, there is a marked saving in threshing labor on a scale which may be sufficient to nullify the demand increasing effect of adopting MV with fertilizer. In addition, where machines are employed, there is evidence from Ranade's (1977) work in the Philippines that average wage rates are reduced. Presumably this is due to the changing task composition of the work performed towards traditionally less well-paid tasks, for example, weeding. This cannot be interpreted as being due to the direct effect of mechanization on the average price of rural labor, although the wage rate has been recorded as declining in real terms in several Asian countries. The latter is evidence that the growth of agricultural labor demand in rice growing areas in the poorer Asian countries has not kept pace with the growth in labor supply. Undoubtedly the adoption of modern rice varieties, fertilizer, and irrigation have ameliorated this position somewhat.

The main gains from the new technology appear to have been made by land operators and landowners rather than by labor. This raises the important issue of whether the institutions organizing the diffusion of the technology have a built in bias towards large land operators and against the small farmers, despite evidence that the latter tend to achieve higher yields with the new varieties. There is also the ancillary question of whether the new technology actually serves to heighten this bias in some way, despite the inherent scale neutrality of modern varieties and chemical inputs. The studies undertaken were not specifically directed to these questions, but they have produced a number of relevant insights. In both the Philippines and Indonesia, similar changes were observed in the institutions governing the harvesting of rice. These involved a shift from traditional systems, in which the harvest was available to laborers willing to work for a traditionally determined share of production, to more restricted arrangements. These new arrangements involve reducing the share of the harvest paid to labor and in various ways controlling access to harvesting work. It is not surprising that labor's share of the harvest would be reduced, since the higher yields associated with MV are not attributable to labor; thus in part, the new technology has provided a stimulus for the abandonment of harvesting arrangements, which in their original form guaranteed the landless some rice. It should be kept in mind that preservation of traditional relationships is increasingly unmanageable, due to the rapid increase in total labor, and particularly landless labor.

The new technology has provided an excuse, as well as a stimulus for erosion of patron-client relationships, which can be interpreted as a breakdown in the traditional arrangements whereby the community assisted its poorer members. The adoption of tractors and threshers reflects something of the same phenomenon, in that it permits farmers to overcome difficulties in adjudicating the issue of who will be hired in a labor surplus situation, and provides yet another incentive for setting aside traditionally recognized rights. From a policy standpoint this is an undesirable secondary consequence of the adoption of these mechanical technologies, especially if their social returns are small, and it underscores the desirability of pursuing policies which keep the gap between private and social returns negligible. Noting that the social cost of mechanical threshing is particularly high, Ranade suggested the possibility of landless laborers forming cooperative units which, with government-backed low interest loans, could purchase mechanical threshers. The landless might then capture a portion of the private benefits accruing from the ownership of labor-saving threshing equipment.

Although the key input of the new rice technology--water, seeds, fertilizer, and insecticides--are highly divisible, can be supplied in small quantities, and are inherently scale neutral, it has nevertheless been widely accepted that there is a bias towards larger holdings in the economic processes set off by the new technology. In part, this is because the means of delivering water do not always lead to equitable distribution; there is a minimum size of holding required to justify the acquisition of tubewells and pump sets.

Where tractors and threshers are important elements of the technology, this problem of technological indivisibility in private ownership becomes even more acute. It is, however, also evident that in certain areas, this large farm bias is reinforced in the provision of credit for the purchase of the divisible inputs; subsidized government credit may be available more readily and cheaply for large landowners with extensive holdings for collateral.

In this situation small farmers, despite their demonstrated industriousness, may be trapped into situations of indebtedness, where they are forced to mortgage or sell their land to larger landowners. Clearly, the new technology has intensified this tendency to increasing concentration of land control, by raising the returns to land and providing the incentive to the larger land operators, who have the economic power, to increase their holdings. It is concluded that strong public policy must be formulated in a manner which will build-on the scale-neutral aspects of agricultural technology, and direct benefits towards small farmers and landless families.

Appendix

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