A Note on Agricultural Mechanization in Indonesia: West Sumatra in Comparison with West Java[1)]

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1. Introduction

Mechanization of agriculture has been going on in Indonesia as in many other developing countries in Asia[2)]. Given the factor endowments in this part of Asia that land is scarce relative to labor, the labor intensive technology, by which productive employment opportunities can be increased, is generally considered by development economists as the appropriate technology[3)]. On this ground, mechanization, which has apparent characteristics of substituting labor, is often blamed as the technology that brings about income inequality in rural areas, working against the income position of rural poor, i. e. small peasants and landless laborers.

Nevertheless, mechanization is definitely going on in such a country as Indonesia that is well known as the country of high population density. What are the factors that bring about the mechanization in the countries in which labor is relatively abundant and the need to provide productive

employment opportunities for the growing labor force is stringent? What are the consequences of mechanization in rural areas; does it really give adverse impacts to the income distribution in rural areas? Is mechanization really an inappropriate technology? Such questions should be asked and answered in the face of rapid mechanization in this part of the world, not only for the sake of enhancing our understanding on the economic mechanism of agricultural development but also for the sake of giving suggestions for formulating an effective policy toward agricultural development in these countries.

Indonesia gives us invaluable opportunities to investigate these questions, since the country has, in her territory, regions of different population density, from Java with the highest density to the outer islands of sparsely populated, and since different types of mechanization have been going on in these regions.

In this paper, we focus our attention on the mechanization in West Sumatra where the population density is not as high as in Java but higher than in other outer islands. Equally important is the fact that agriculture in Sumatra, especially rice farming, has experienced in recent years rapid development with a distinct pattern of mechanization, that is, mechanization of the post harvesting activities as compared to mechanization of land preparation in West Java and in many other rice growing regions in tropical Asia.

An investigation into the process of mechanization in rice farming in West Sumatra, while comparing it to that in West Java, will give us insights on the questions raised above, i. e., what are the factors that determine the diffusion of mechanical technology, what are the consequences of mechanization, and whether or not mechanization is an appropriate technology in a country of relative labor abundance such as Indonesia.

The data used in this paper were collected mainly through an interview survey conducted in West Sumatra in 1984. The number of sample farmers covered in the survey was 145, including owners, users and non-users of winnower/thresher who were drawn from six villages (*desa*) in three regencies (*kabupaten*) of West Sumatra. Additional information was obtained from 54 farm laborers and 67 workshops who fabricated these equipments[4]. Other data on rice farming in West Sumatra as well as in West Java from various sources will be used intensively for supplemental and comparative purposes.

2. Agriculture and Rice Farming in West Sumatra

First, let us observe briefly agriculture and rice farming in West Sumatra. The available information in these respects is rather scanty since the major attention in the past agrarian studies in Indonesia has been directed to the agriculture on Java. In order to facilitate our general understanding on agriculture and rice farming in West Sumatra, those in West Java for which we have more solid ideas shall be taken up for a comparative purpose (Fig. 1).

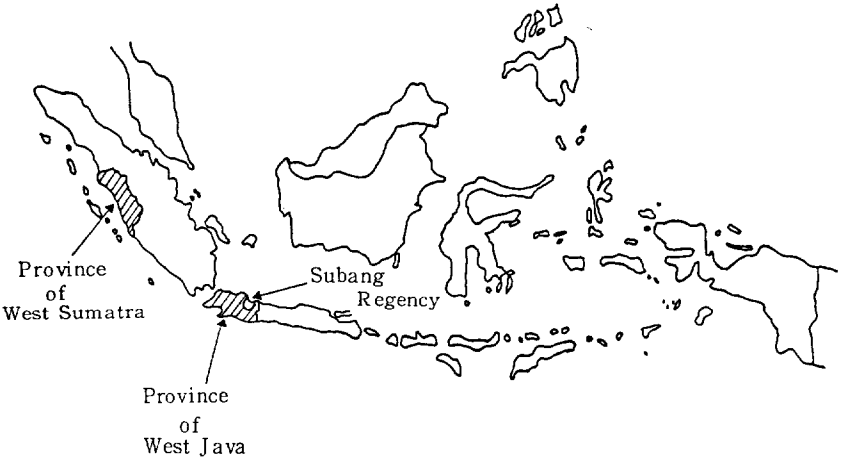

Figure 1. Map of Indonesia

(1) Agriculture and agrarian structure

Some statistics on agriculture in both provinces are summarized in Table 1.

West Sumatra as an agricultural region is about one sixth of West Java in terms of absolute size of agricultural land area and number of farms. It has a lower man-land ratio than West Java. Based on the 1973 population census data, the man-land ratio in agriculture was 8.5 persons per hectare in West Sumatra, whereas it was 14.9 persons per hectare in West Java (Yonekura [43, 194]). Although there are such differences in the absolute size and in the population pressure against land, both provinces are two of the most productive agricultural regions in Indonesia. It is common to the two regions that crop farming based on rice production on irrigated lowland is the main constituent of its agriculture and that the majority of farmers

Table 1. Some statistics on agriculture in West Sumatra in comparison with West Java, 1983

	West Sumatra	West Java
1. Agricultural land area (10,000ha)	33	178
2. Number of farms (10,000)	51	355
3. Average operated area by land use (ha/farm):		
Irrigated lowland; two crops	0.15	0.15
Irrigated lowland; one crop	0.08	0.03
Unirrigated lowland	0.10	0.09
Upland	0.17	0.16
Others	0.15	0.07
Total	0.65	0.50
4. Size distribution of farms (%):		
~0.25ha	17	43
0.25~0.50	21	23
0.50~1.00	31	19
1.00ha~	31	15
Total	100	100
5. Distribution of farms by land tenure status[1] (%)		
Owner	74	71
Owner/tenant	9	11
Tenant	17	18
Total	100	100
6. Principal sources of farm household income (%):		
Food crops	87	83
Other agriculture	5	4
Non-agriculture	8	13
Total	100	100
7. Percentage of rice planted area by varieties[2] (%):		
MV resistant to BPH biotype 1	16	10
MV resistant to BPH biotype 1 and 2	47	66
MV non resistant	9	7
National/local	28	17
Total	100	100
8. Average fertilizer use by type (kg/ha):		
Urea/ZA	111	210
TSP/DSP/DAP	73	95
Kcl	5	2
Total	189	307
9. Density of draft animal and agricultural machinery[3] (No./1000ha)		
Draft animal	682	451
Hand tractor	0.6	3.3
Riding tractor	0.6	0.3
Thresher	0.9	1.8[4]
10. Rice yield (t/ha)	4.06	4.42

1) For 1981. Figures for West Sumatra are for a village in Regency of Agam and 'owner' includes small non-cultivaing land owners.
2) BPH=brown plant hopper.
3) For 1982.
4) Includes pedal threshers. Portable threshing machines commonly used in West Sumatra are rarely seen in West Java.
Source: BPS Agricultural Census except #5. For #5, West Sumatra; Iwasaki [23, 19] and West Java; Yonekura [44, 9].

are extraordinarily small-sized owner cultivators with the average land holding of 0.50–0.65 hectares. Including owner-*cum*-tenant cultivators, more than 80 percent of farmers are cultivating owned land.

It should be noted, however, that the percentage share of small farmers cultivating less than 0.5 hectare is nearly 70 percent in West Java while it is less than 40 percent in West Sumatra. This fact may indicate different degrees of class differentiation in rural areas between the two regions. Besides farmers, landless laborers who obtain their livelihood mainly from hired labor works in farming are commonly found in both regions, but the degree of this landlessness is much higher in West Java. Kano [28] estimates that the percentage of non-farm[5] households in rural West Java in 1973 was 34 percent as compared to 12 percent in West Sumatra[6]. It could be said that, taking this fact into account, class differentiation in rural areas in West Java is much more progressed than in West Sumatra.

West Sumatra is the land of Minangkabau, an Indonesian ethnic group, which is famous for its matrilineal kin group (*suku*) society having a unique system of land use and inheritance (*pusako*) regulated under the customary law called *adat*[7]. The different degree of peasant class differentiation between West Sumatra and West Java may stem partly from such socio-cultural differences between the regions. However, more basic factor should be that the population pressure in West Java has been much higher than in West Sumatra.

It is also remarked that, although the majority of farmers are owner operators, there exist tenant cultivators of about 20 percent in both provinces. Moreover, it is said that the share of tenant farmers has been increasing in recent years[8]. However, factors that brought about the increase in tenant farmers seem to differ between the two provinces. While in West Java an increase in population pressure against the limited land resource, which has resulted in an increase in land rent relative to wage and promoted class differentiation in rural areas, is considered as responsible for this increasing trend (Hayami and Kikuchi [17, 171–208]), in West Sumatra it is said that labor shortage due partly to the deep rooted tradition of out-migration of the male labor force peculiar to Minangkabau and partly to an increase in employment opportunities in the non-farm sector in recent years is the major reason why the tenant farming has increased[9].

It should be mentioned that, although the province of West Sumatra as a whole forms a productive agricultural area, regional differences in agriculture do exist within the province. The province consists of eight regencies (*kabupaten*) (Fig. 2). The agriculture is not homogeneous across the

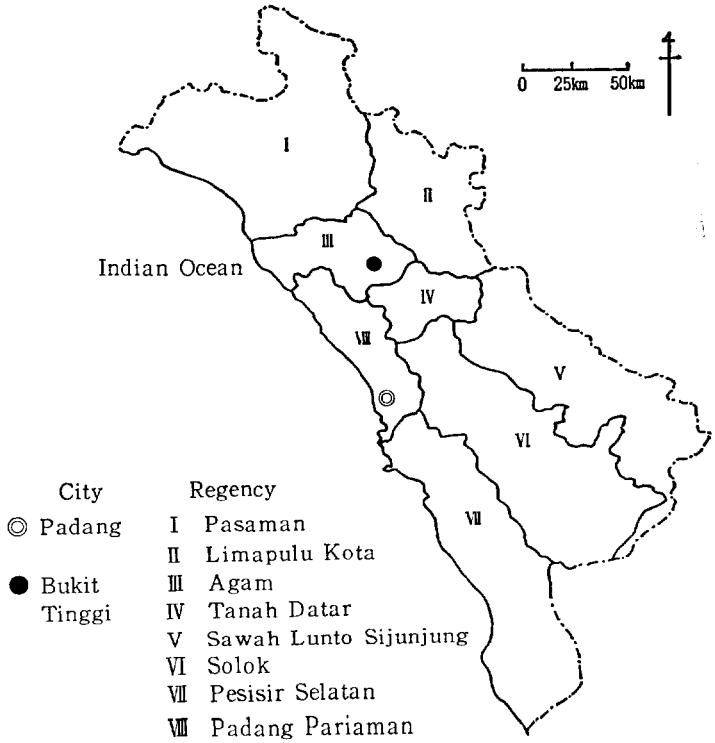

Figure 2. Map of West Sumatra

regencies and each regency has a different development history. At least, two regions are distinguished; the *Darek* and the *Rantau*. The former region, consisting of three highland regencies (Agam, Limapulu Kota and Tanah Datar), is the traditional cultural heartland of Minangkabau having a long history since even before the Minangkabau Kingdom in the fourteenth century. The latter region consists of the outlying regencies to the south, east and west of the *Darek* region, including the coastal plain on the Indian Ocean side of West Sumatra and the hilly regions to the south and east. The term *rantau* literally means any area outside the *Darek* populated by large number of Minangkabau migrants. In terms of land use for agriculture, the *Darek* is dominated by lowland paddy, while some parts of the *Rantau* by commercial crops such as rubber and coconut and by upland (Table 2)[10].

Table 2. Agricultural land use in West Sumatra by district, 1972[1)]

	West Sumatra total	District							
		Agam	Pasaman	Limapulu Kota	Tanah Datar	Padang/ Pariaman	Solok	Pesisir Selatan	Sawah Lunto/ Sijunjung
1. Lowland and upland	60.2	77.0	68.8	88.4	71.7	28.8	82.3	82.2	23.5
a. Lowland	43.7	54.5	62.2	44.6	58.0	22.6	51.4	76.1	21.5
b. Upland(food crops)	7.2	2.0	2.8	5.9	10.3	2.6	29.2	1.3	1.9
c. Shifting cultivation	9.3	20.6	3.8	37.9	3.3	3.6	1.8	4.8	-
2. Estate crops	33.9	22.4	38.3	6.2	27.2	54.0	16.8	17.7	70.9
a. Rubber	13.0	0.7	29.1	0.6	6.6	0.3	10.1	2.5	70.9
b. Coconut	15.1	9.5	0.7	0.1	0.8	53.3	-	12.1	-
c. Coffee	1.5	1.7	3.2	2.3	0.4	-	3.4	2.3	-
d. Others	4.3	1.5	5.3	3.2	19.4	0.4	3.3	0.8	-
3. Vegetables	5.9	10.5	1.0	5.5	1.1	17.2	0.8	0.2	5.7
4. Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Agricultural land area(1000ha)	519.8	54.3	58.7	68.9	43.2	127.1	73.6	38.4	55.5
Ratio of ag. land area to total land area(%)	12.6	25.1	7.8	19.6	33.2	15.7	10.9	6.5	9.0
Rice land per capita(ha)	...	0.12	0.15	0.14	0.12	0.08	0.11	0.11	0.10
Rice self sufficiency rate(%)	...	85.4	110.0	110.3	92.1	60.9	80.9	84.0	74.3

1) Percentage compositions in the total agricultural land use.
Source: Yonekure [43, 215] and Kahn [25, 66].

(2) Changes in rice farming

It is well known that the rice production in Indonesia has increased rapidly in the last decade, finally resulting in rice self-sufficiency in the early 1980s. The development of rice production in West Sumatra has kept in perfect step with that in Indonesia as a whole. Since 1961, rice production in West Sumatra has increased at an annual growth rate as high as 4.2 percent (Table 3).

Irrigation development and diffusion of new seed-fertilizer technology are the major factors behind this development in West Sumatra, as in Indonesia as a whole. Irrigation development was especially distinct during the 1960s to the early 1970s (Yonekura [45]). Not only increases in yield per harvested area but increases in harvested area through rice double cropping can be brought about by irrigation. The annual growth rate of harvested area for lowland paddy was as high as 4.1 percent for the 1960s.

The development of irrigation infrastructure in the 1960s has also provided conditions on which the new seed-fertilizer technology could be successfully introduced after the late 1960s. However, the diffusion process of modern varieties (MV) of rice was not a smooth process. For rice production in Indonesia, the early 1970s was the period of heavy infestation of insect and pest, such as tungro disease and brown plant hopper (BPH), for which early MVs were very susceptible. Especially, damages by BPH were so intense that skepticism was cast over the use of MV (Bernsten *et al.* [4]). It was after the introduction of new MV strains resistant to BPH in the mid-1970s that the use of MVs contributed significantly to the steady increase in rice yield. In West Sumatra, these BPH resistant MVs had diffused rapidly, and more than 60 percent of rice areas were planted with these MVs in 1983 (Table 1).

Fertilizer use has also been intensified. On the average of all farms, nearly 200 kilograms of fertilizers were applied per hectare in 1983 (Table 1). Although one reason for such a high level of fertilizer use is, of cause, the diffusion of fertilizer responsive MVs, another reason behind it is that a government program aimed at dissemination of the seed-fertilizer technology was successfully implemented. Under this program called BIMAS, fertilizer prices were kept low and rice farmers were provided with low interest institutional credits.

As the result of these technological changes, rice yield per hectare has increased rapidly in the 1970s with an annual growth rate of around 3 percent (Table 3). Unlike in the 1960s during which more than 80 percent of rice production increase was brought about by the increase in harvested

Table 3. Development of rice production, harvested area and yield per ha in West Sumatra[1]

	Total			Lowland paddy			Upland paddy		
	Production (1000t)	Harvested area (1000ha)	Yield per ha (t)	Production (1000t)	Harvested area (1000ha)	Yield per ha (t)	Production (1000t)	Harvested area (1000ha)	Yield per ha (t)
1961	567	196	2.89	519	172	3.02	48	24	1.98
1964	626	209	3.00	573	183	3.14	53	26	2.01
1967	708	243	2.91	661	220	3.01	47	23	2.01
1970	819	265	3.09	790	247	3.20	30	19	1.58
1973	904	265	3.41	886	254	3.49	18	11	1.60
1976	959	263	3.65	941	253	3.73	18	10	1.76
1979	1123	286	3.93	1110	278	3.99	14	8	1.76
1980	1240	296	4.19	1226	289	4.24	14	7	1.90
Growth rate(%)[2]									
1961~80	4.2(100)	2.2(52)	2.0(48)	4.6(100)	2.8(61)	1.8(39)	−6.4(100)	−6.3(98)	−0.1(2)
1961~70	4.2(100)	3.4(81)	0.8(19)	4.8(100)	4.1(85)	0.7(15)	−5.2(100)	−2.8(54)	−2.4(46)
1670~80	4.2(100)	1.1(26)	3.1(74)	4.5(100)	1.6(36)	2.9(64)	−7.5(100)	−9.8(123)	1.7(−23)

1) Three year averages centering the years shown.
2) Compound growth rates per year. Figures in parenthesis are persentage compositions.
Source: Yonekura [45, 46].

area, more than 70 percent of the total production increase in the 1970s was accounted for by the increase in yield per hectare[11].

3. Mechanization in Agriculture

Another major change in rice farming in West Sumatra not mentioned in the previous section is mechanization, to which we now turn.

(1) Agricultural mechanization in West Sumatra and West Java

The first process mechanized in rice production processes in Indonesia was milling, which began in the early 1970s. Rice pounding, that used to be carried out by women in rural areas, was replaced swiftly and thoroughly by machine milling in Java and elsewhere in Indonesia[12]. In West Sumatra, it replaced partly rice pounding and partly water milling (Yonekura [45]).

Mechanization of rice production has recently proceeded to land preparation and post harvest processes; hand tractor and threshing machine. A peculiar feature of mechanization at this stage is a regional difference in machines adopted by farmers. Tractorization in land preparation has been going on in both provinces, but its degree is much higher in West Java[13]. In contrast, threshing machine has been rapidly introduced in West Sumatra, but it is still rarely found in West Java.

As shown in Table 1, the density of hand tractors in 1983 was five times as high in West Java as in West Sumatra, whereas density of draft animals was much higher in West Sumatra. It is indicated in the table that the diffusion of thresher was higher in West Java, but this is because 'thresher' here includes pedal threshers. Threshing machines are almost in non-existence in West Java, while almost all threshers in West Sumatra are threshing machines of portable type.

(2) Changes in technology and labor hiring systems

As we have seen so far, rice farming in West Sumatra has experienced significant technological changes including mechanization in the post harvesting process. No doubt these changes have exerted immense influences on the traditional labor hiring systems. In this section, let us observe changes in the labor hiring systems associated with technological changes in land preparation and harvesting. Here too, West Java will be treated as a standard for comparison.

Major changes in technology and labor hiring systems in land preparation and harvesting are summarized in Table 4 for the periods before and

Table 4. Changes in major technology and labor hiring systems in land preparation and harvesting before and after MV introduction, West Sumatra and West Java[1)]

	Before MV (~1968)		After MV (1968~)	
	West Sumatra	West Java	West Sumatra	West Java
Land preparation	* Human labor * Draft animal · Communal labor (*Julo-julo*) · Commission (*Kongsi* group)	* Human labor * Draft animal · Communal labor · Commission (*Bolongan*)	* Human labor * Draft animal * Tractor · Kongsi group • Day labor (*Harian*)	* Human labor * Draft animal * Tractor · *Bolongan* · *Harian* · Permanent · *Ceblokan*
Harvesting:				
Cutting	* Sickle · *Julo-julo* · *Bawon* · *Kongsi* group	* *Ani-ani* knife · *Bawon*	* Sickle • *Bawon* · *Kongsi* group • *Harian*	* Sickle · *Bawon* · *Ceblokan* · *Tebasan*
Threshing	* Foot • Share	* No threshing · (with harvesting)	* Foot * Beating * Thresher · Share	* Beating · (with harvesting)
Winnowing	* Wind · Share	* No winnowing · (with harvesting)	* Wind * Lumbo · Share	* Wind · (with harvesting)

1) * stands for technology and · stands for labor hiring systems.

after the MV introduction. It should be mentioned first that traditionally in Indonesia, as in many other rice growing regions in the tropics, land preparation was carried out by family or exchange labor. In contrast, harvesting, in many rice growing regions, was a sort of communal activity in which everyone could participate for a share of harvest. Of the two provinces, West Java typically belongs to this type. Changes in labor hiring systems occur as shifts from these traditional institutions.

Land preparation

The traditional technology for land preparation was animal plowing/harrowing supplemented by manual hoeing in both provinces. Labor used in this process was mainly family labor or exchange labor for mutual help among farmers. However, animal plowing by commission or custom hiring (*bolongan*) did exist for farmers who owned no draft animal. In West Sumatra, this exchange (or communal) labor system is called *julo-julo*, and works under commission contract were often taken by a labor gang called *kongsi*[14].

After MV, tractors were introduced in both provinces. Almost without exception, tractor land preparation is carried out on commission basis[15]. Unlike custom hiring using draft animal in which the owner of the animal usually does the works, laborers hired by owners carry out the works in the case of tractor custom hiring. Day labor (*harian*) in the table partly refers to these hired laborers paid with daily wage.

In West Sumatra, tractorization is not as distinct yet as in West Java, and the majority of land preparation is still done by draft animals. However the communal labor arrangement for land preparation has gradually disappeared, being replaced by commission arrangement contracted by individual animal owners. Besides *kongsi* group commission, day laborers are now hired for manual land preparation, replacing family and communal labor.

An increase in commission arrangements in replacement of communal labor arrangements and emergence of day labor system are observed commonly in land preparation in West Java. However, the changes there are more complex. At least, two changes specific to West Java should be mentioned. First, the incidence of permanent (attached) labor appears to be increasing. A permanent laborer hired by a farmer for a season or seasons engages in all farm tasks that are supposed to be carried out by the farm operator, actual works as well as supervision of hired laborers, and land preparation is one of them. Farmers who employ permanent laborers are usually the large farmer cultivating more than 2 hectare, 'huge' farmer in

the Java standard, so that the incidence is found in areas where class differentiation has progressed[16].

Second, in some areas in West Java, a part of land preparation, especially harrowing and leveling, is carried out by hired laborers employed under *ceblokan* system, a variant of labor hiring system for harvesting which will be explained in the following sub-section. Here, it should only be noted that, in areas where this system is emerging, a regressive technological change opposite to tractorization, *i. e.* a shift from animal to manual land preparation, is often observed.

Harvesting and post harvesting

This process can be divided into, at least, three different activities; cutting, threshing and winnowing. The *ani-ani* knife, a tool traditionally used for cutting rice at panicle in West Java, as in many other parts in Java and elsewhere in Asia, has been quickly replaced by the sickle as MVs have diffused (Hayami and Hafid [16]). In contrast, sickle cutting was widely practiced even before MV introduction in West Sumatra. It appears that the *ani-ani* used to be used in West Sumatra too, but that the switch to the sickle occurred decades ago[17].

When the *ani-ani* is used for cutting, harvested paddy is stored with paddy stalks bound up and directly brought to milling process, so that there was no threshing process in West Java before MV. When threshed, for instance, to obtain seeds, foot-rubbing threshing was practiced. After shifting to sickle cutting, beating threshing by hands against a board has become popular. In West Sumatra where foot-treading threshing was practiced before MV, the beating method emerged after the introduction of MVs that are more susceptible to shattering, and, further, machine threshing by the protable thresher was added to the list of threshing methods after 1980.

Winnowing is a process accompanied with sickle cutting. In West Java since the introduction of beating threshing and in West Sumatra since even before MV, a common practice has been wind winnowing. In addition to the traditional method, the hand operated winnower called *lumbo* has been diffused in West Sumatra since the mid-1970s.

In accordance with changes in technology, labor hiring systems associated with harvesting and post harvesting processes have experienced drastic changes. Especially in Java, these changes have been dramatic and diverse[18]. Traditionally rice harvesting in Java has been performed by hired labor employed under a sort of commission system in which laborers receive a certain share of output as wage in kind (*bawon*)[19]. The commission

system is different from that for land preparation in which wage payments are based on areas worked. The deep-rooted labor hiring system for rice harvesting in West Java as well as in other parts of Java when the *ani-ani* was used for cutting was this open *bawon* system in which everyone could participate. When cut by the *ani-ani*, threshing and winnowing are usually not performed. Even when these activities are added according to the shift to the sickle, a group of harvesters performs from cutting through winnowing and receive *bawon*.

Recent changes from this traditional *bawon* take diverse forms in West Java. First, without changing the framework of *bawon* system, reductions of harvesters' share occurred widely from the traditional level of 1/5—1/7 to 1/10 or even to 1/15. Second, the open *bawon* system was changed to the closed one in many areas, closed in such ways as limiting to villagers only, putting a maximum limit, and limiting to invitees only. Third, as a variant of closed *bawon* system, *ceblokan* system diffused in some areas. In this system, the participation to harvesting is limited to those who perform extra services without pay for such tasks as transplanting, weeding and harrowing[20]. Forth, a system called *tebasan*, in which farmers sell their standing crops to middlemen called *penebas* some time before harvest, was adopted in some other areas. In this system which is said to be totally out of the *bawon* framework, rice harvest is performed by laborers whom the *penebas* hires[21].

The traditional harvesting system in West Sumatra has characteristics a bit different from that in West Java. In West Sumatra where the sickle had been used since long before the MV introduction, the harvesting process has consisted of three activities; cutting, threshing and winnowing. Unlike in West Java where the *bawon* system has been deeply rooted and even after the shift to the sickle the three activities as a whole are carried out by the same group of harvesters, these three activities in West Sumatra are considered as tasks that can be performed separately by different groups of laborers. The *bawon* system existed and there were cases in which all tasks were performed by the same group. However, there were also many cases in which the tasks were carried out separately by different groups. In such cases, different harvesters' shares specific to each activities were applied. Cases in which all or some of these activities were performed by family and exchange labor (*julo-julo*) were also not uncommon (Kahn [25, 66–70]).

Such features of the traditional harvesting system in West Sumatra affected to the directions of its recent changes. Even after the introduction of the threshing machine and the winnower, these two tasks are performed

under a *bawon* type commission system where a certain share of output worked is paid as wages and service fees to the machines. Laborers receive a certain percentage of paddy out of the share. When these machines are used, the cutting becomes a completely separate activity performed usually under *bawon.* However, farmers who adopt the day labor system for cutting, which existed even before mechanization, have been increasing.

(3) Diffusion of *lumbo* and thresher in West Sumatra

Before proceeding to a simple economic analysis of agricultural mechanization in the following chapter, let us make a digression for describing some more details of post harvest mechanization in West Sumatra.

Lumbo

The *lumbo* (wooden-made hand-operated winnower) has a longer history of adoption by farmers than the mechanical thresher. It is said that the original model of the *lumbo* was developed in 1964 by a primary school teacher in Payakumbuh, Limapulu Kota, drawing the first design from the old water-wheel rice mill then used. After several modifications through field trials, the present design was established by 1970, and since then it has diffused widely in the province.

The *lumbo* is produced locally throughout the province by craftsmen as a small cottage industry. Its price varies according to trade marks, ranging in 1984 from Rp. 35,000 to Rp. 75,000 with 1 to 6 month guarantee for the product.

Owners of *lumbo* are medium-sized farmers cultivating, on the average of our samples, 0.65 hectare (Table 5). They own it not only for their own use but also for custom hiring. As a matter of fact, 70 percent of the owners answered that they acquired *lumbo* for raising additional income from its custom hiring. A simple breakeven point analysis assuming Rp. 75,000 of *lumbo* price indicates a breakeven quantity to be winnowed per unit of *lumbo* of 1 tons/year[22], whereas the realized capacity per unit in 1984 was, on the average, 47 tons/year. All this fact suggests that the market for *lumbo* service has been rapidly developed.

For the users side of *lumbo*, it should only be noted here that the major reasons of its adoption raised by the users are 'shortage of labor', 'lower cost', and 'quickness of operation'.

Thresher

In contrast to the *lumbo* diffusion that is a purely grassroot phenome-

Table 5. Reasons for purchase/use/non-use of lumbo and thresher raised by sample farmers(%)[1]

	Lumbo			Thresher		
	Owner-user[2]	Service-user[3]	Non-users	Owner-user[2]	Service-user[3]	Non-users
Average size of operation(ha)	0.65	0.92	0.46	0.94	0.47	0.34
Reasons for purchase or hire:						
Source of income	70	-		65	-	
Shortage of labor	39	56		60	68	
Lower cost	57	63		90	45	
Lower losses	52	48		45	52	
Quickness of operation	83	93		75	90	
Cleaner result	39	41		-	-	
Reasons for non-use:						
Not known			39			20
Not available			0			69
Too costly			0			52
Far from road			50			21
Enough hired labor			14			14
Enough family labor			0			3

1) Percentage of sample farmers who said 'yes', allowing more than two answers. - stands for not applicable or not asked.
2) Farmers who purchase and use.
3) Farmers who use in custom service.

Table 6. Diffusion of threshers in West Sumatra by regency

Regency	1980	1982	1983
Agam	6	59	141
Pasaman	1	22	73
Limapulu Kota	3	13	33
Tanah Datar	4	20	42
Padang Pariaman	2	49	164
Solok	1	14	44
Pesisir Selatan	3	12	33
Sawah Lunto Sijunjung	5	9	26
Total	25	189	556

Source: Dinas Pertanian, West Sumatra.

non, the thresher was first introduced in this province under a formal project called 'Industrial Extension Project' undertaken jointly by the Indonesian Directorate of Food Crops Production and the International Rice Research Institute (IRRI), in which West Sumatra was selected in 1979 as a pilot area for field extension and demonstration works. Other organizations such as the Provincial Agricultural Department and the Bank of Indonesia were also mobilized for assisting the project. It is interesting that the farm equipments this project brought in for technology transfer include not only the threshing machine but the hand tractor. After several demonstration operations of the machines and seminars for fabricators/workshop owners and leader farmers were held, the thresher began to disseminate in this province rapidly. The number of threshers in West Sumatra increased from 25 in 1980 to 556 in 1983 (Table 6).

Localization of production of the IRRI type portable thresher was rather quick. The first local-made thresher appeared in 1981, and at least, 14 workshops located in different regencies in West Sumatra engaged in fabrication of the thresher in 1983[23]. The selling price of the thresher which is usually provided with one month to one year guarantee was Rp. 700,000 for the 5 hp model and Rp. 800,000 for the 7 hp model in 1984.

The farmers who own the thresher are large farmers cultivating, on the average, 0.94 hectares (Table 5). Similar to the *lumbo*, they own it not only for their own use but for custom hiring; 65 percent of the owners pointed out that the acquisition of thresher was for an additional income source. It may be worth mentioning that only 6 percent of the sample

thresher owners bought it using a bank loan[24]. The custom hiring of the thresher is a lucrative business. It is estimated that the breakeven point for a 5 hp thresher is 24 tons/year[25]. In comparison, the realized work load per unit of thresher was 62 tons per year on the average in 1984. Some owners recovered the acquisition cost of a thresher by custom hiring within one season[26]. It could be said that the market for thresher service too has developed fast and well in this region.

The reasons for thresher adoption raised by the users are similar to those for the *lumbo*; 'quickness of operation', 'shortage of labor', and 'lower cost' (Table 5). As compared to the *lumbo*, more users pointed out 'shortage of labor' and 'lower cost' as reasons for thresher adoption.

Regional pattern of diffusion

It should be noted that, although both *lumbo* and thresher have diffused rapidly in West Sumatra, regional differences in their diffusion are substantial as shown in Table 7. As to the year of thresher introduction, almost all sample villages were in line. In the case of *lumbo*, however, the year of introduction varies from 1975 to 1981. The difference is large even in a regency. For instance, in Agam, one of the sample villages adopted it in 1976, while the other village did in 1981.

After the introduction of *lumbo* for winnowing and thresher for threshing, there co-exist typically three post harvesting systems in terms of techniques adopted in the two processes in this region. First system is the traditional one with foot threshing and wind winnowing. Second is an intermediate system adopting the beating threshing and the *lumbo* winnowing. Third system consists of both of newly introduced machines; machine threshing and *lumbo* winnowing.

Regional differences in the adoption of these three systems are large. Third system is the major one in three villages, one in Agam and two in Padang Pariaman, adopted by more than 70 percent of farmers. While second system is adopted by an overwhelming majority of farmers in one of the villages in Sawah Lunto Sijunjung, nearly all farmers in one of the villages in Agam still operate under the traditional system. The other village in Sawah Lunto Sijunjung shows yet a different case in which three systems are evenly distributed. From our field observation, differences in extension services and in access to non-farm income earning opportunities among the regions seem to have certain impacts on the regional differences. However, more investigation is definitely needed to identify factors that determine this regional pattern of post harvesting technology adoption.

Table 7. Changes in post harvest technology and wage/custom rate for harvesting activities in the sample villages of West Sumatra

	Agam		Padang Pariaman		Sawah Lunto Sijunjung	
	Sago	Kapau	Buluh Kasok	Laras Nan Panjang	Sikayen	P. SibuSuk Selatan
1. Year of introduction						
Lumbo	1981	1976	1977	1977	1979	1975
Thresher	1981	1981	1980	1981	1981	1981
2. Wage/custom rate						
a. Before *lumbo*[1)]						
Sickle harvest (wage, liter of rice)	3.5	mh	4	4	3.5	mh
Threshing (custom rate, %)	8	mh	5	7	10	mh
Winnowing (custom rate, %)	2.5	mh	3	3	4	2
b. 1980/81						
Sickle harvest (liter of rice)	-	4	4	4	4	4
Threshing(%)	-	-	7	7	10	6
Winnowing(%)	-	1	3	3	4	2
c. 1984						
Sickle harvest (liter of rice)	4.5	4.6	4.6	4.6	4.6	4.6
Threshing(%)	8	10	8	7	10	6
Winnowing(%)	2.5	1	3	3	4	3
3. Percentage of farmers by post harvest technology(%)						
Foot threshing+wind winnowing	5	98	0	25	35	1
Beating threshing+*lumbo*	0	0	15	0	30	95
Thresher+*lumbo*	95	2	85	75	35	4
4. Average farm size(ha)	0.62	0.34	0.28	0.38	0.25	0.62

1) mh=mutual help (*gotong royong*).

4. Inducements to and Consequences of Mechanization

What is the basic factor that induced the agricultural mechanization in West Sumatra and West Java? What consequences have been brought about by the mechanization? Why the post harvest mechanization in West Sumatra and the tractorization in West Java? Although available data on hand are too fragmental to answer these questions fully, we try, to the extent possible, to sketech out some ideas on these points.

(1) Simple economics of mechanization

Let us approach to the first question through an examination of the rural labor market and the labor-capital substitution process.

West Java

First, we look into the tractorization process in West Java by taking a rice village in Subang Regency as a typical case. This rice mono-culture village, located on the coastal plain along the Java Sea where the tractorization has been most progressive, has a relatively short history; its establishment goes back only to the 1920s. Before that time, the village area used to be a wild area, and the early settlers practiced very extensive farming called *gogolanca*, reflections of which can be found now in a comparatively large operational size of the village farmers and in a relatively polarized village structure; the average farm size is 0.87 hectare and more than 60 percent of village households are landless farm laborers[27].

Since the last World War, the agriculture in this village has experienced significant technological changes. At least four major changes should be mentioned. First, a local irrigation system was constructed in the 1950s, by which the village farm land became paddy fields irrigated during the wet season. Second, the construction of Jatiluhur Irrigation System, the largest irrigation system in Java, made rice double cropping possible for all the village paddy fields in the early 1970s. Third, the MV technology was successfully introduced in parallel with the second irrigation improvement. Fourth, the tractorization has been rapidly going on since the late 1970s.

Because of these technological changes, the land productivity in this village has increased significantly[28]. As shown in Table 8, the average rice yield per hectare per crop increased by 60 percent from 1968–71 to 1981. Taking the increase in cropping intensity into account, the yield per hectare

per year increased by more than 100 percent[29]. It is said that the rice yield per crop before the first irrigation inprovement in the 1950s was about 1.5 tons per hectare. Compared to this level, the land productivity in this village increased five times within three decades.

It should be noticed that these technological changes, except the last one, have the nature of increasing the demand for labor. Above all, the second irrigation improvement that enabled the rice double cropping would have had a strong impact on the labor demand in the village agriculture. From 1968–71 to 1978/79 (just before the substantial diffusion of the tractor began), labor input per hectare increased by 10 percent per crop and by 50

Table 8. Changes in technology, inputs and their prices for land preparation in rice production in a West Java village, 1968-71, 1978/79, and 1981

	1968-71	1978/79	1981	% change from 1968-71 to 1981
Multiple-cropping ratio	1.5	2.0	2.0	33
MV adoption(%)	7	100	100	1429
Rice yield(t/ha)	2.4	3.4	3.8	58
Labor input(hours/ha)				
Land preparation	219	233	227	4
Total(pre-harvest)	638	701	686	8
Draft animal input[1](days/ha)	9.6	13.2	1	−90
Tractor input[1](hours/ha)	0.5	na	16.0	3100
Paddy price(Rp/kg)	19.3	67.5	85.0	340
Nominal input price:				
Labor wage rate[2](Rp/day)	153	775	1000	554
Carabao rental rate[3](Rp/day)	170	950	na	459[6]
Tractor rental rate[4](Rp/ha)	5360	na	26800	400
Real input price[5]:				
Labor wage rate(kg/day)	7.9	11.5	11.8	49
Carabao rental rate(kg/day)	8.8	14.1	na	60[6]
Tractor rental rate(kg/ha)	278	na	315	13

1) Input for land preparation.
2) Wage rate for land preparation, including the imputed value of meals served.
3) Net rental for carabao excluding payments for labor.
4) Gross rental for tractor including payments for labor.
5) Nominal price divided by paddy price.
6) Change from 1968-71 to 1978/79.

Source: Hayami and Kikuchi [17, 201-203] and Kasryno *et al.* [29, 95].

percent per year (Table 8). It is important to note that such an increase in the labor input was accompanied by a rise in the real wage rate. The real wage rate rose by 50 percent in the last decade.

As to the supply side of labor, the population of the village is estimted to have increased from 1940 to 1980 at an annual growth rate of 4 percent. Such a rapid increase in the village population is due partly to a high natural rate of population growth in this area as compared to other areas and partly to large in-migration to the village. Two times of irrigation improvements in the past induced two waves of in-migration into the village area, and even now a significant portion of farm hired labor works in the area is carried out by seasonal migration laborers[30].

Under these circumstances, a rise in the real wage rate in agriculture with the concomitant increase in the labor input indicates that the increase in labor demand due to the technological changes has exceeded the increase in labor supply. As a matter of fact, labor shortage during the peak season of labor demand for rice production is an often-heard complaint from farmers in spite of large influx of migrants in the past and of heavy presence of migrant laborers at present. The permanent labor arrangement explained in the previous chapter is a way to cope with the labor shortage, adopted by large farmers in this area.

The fourth technological change in this area, *i. e.* the tractorization, has been quite rapid. The use of tractors was almost negligible in around 1970 but it increased to 16 hours per hectare per crop season in 1981 (Table 8). At present, virtually all farmers in this village adopt the tractor land preparation and more than 90 percent of paddy fields in the area is cultivated by tractors. In contrast, the use of draft animal for land preparation declined dramatically toward the early 1980s.

The often-mentioned factors that induced this rapid diffusion of the tractor are the increasing difficulty to raise the water buffalo due to the rice double-cropping after the second irrigation improvement and the necessity to shorten the cultivation period as much as possible because of the tight scheduling of water in the Jatiluhur Irrigation System (Nehen and Wills [33, 16–21]). More basic, however, would be the rise in agricultural wage rate due to the increase in the demand for labor resulted from the rice double-cropping and the diflusion of MV technology. The rise in the wage rate has been far more rapid than that in the tractor rental rate (Table 8), so that the price of labor relative to tractor has risen sharply[31]. It is the tractorization in this area that is nothing but a substitution process between labor and capital induced by the change in relative price between them.

A smooth substitution between production factors according to price signals is economically desirable so long as the related factor markets function well. The information at hand does not allow us to conduct a rigorous check of the workings of labor and capital markets in the study area. However, there are some supporting evidences, though fragmental, that indicate good performance of the factor markets. For instance, as mentioned earlier, almost all tractor land preparation in this area is performed by custom hiring except a few large farmers who own a tractor (Kasryno *et al.* [29], Nehen and Wills [33]). This means that within several years of its diffusion the market for tractor rental service has well developed. Existence of such a rental market eliminates the indivisibility inherent to the use of large fixed capital such as the tractor, and prevents associated imperfection from arising. It is also reported that the rural labor market is competitive in this coastal area with a high mobility of the rural labor force (Colter [11], Nehen and Wills [33, 44–52]).

An additional supporting evidence on the workings of rural labor market is supplied in Table 9 that shows how the labor market is adjusted, through changes in labor hiring systems, for a disequilibrium arisen mainly out of the technological changes in rice production. As explained in the previous chapter, labor hiring systems for rice harvesting in West Java have experienced drastic changes. In the study area, the change occurred, within the traditional open *bawon* system, in a direction to reduce gradually the harvesters' share. The traditional level of harvesters' share in this village used to be 1/5. After the first irrigation improvement in the 1950s, it was

Table 9. Imputed wage rate for havesting labor in a West Java village, wet season, 1978/79

	Bawon 1/7[1)]	Bawon 1/10[1)]
Labor input by harvesters(hours/ha)		
Cutting-threshing-winnowing(1)	258	258
Harvesters' share[2)](kg/ha)(2)	557	390
Imputed wage rate(kg/hour)(2)/(1)	2.16	1.51
Market wage rate[3)](kg/hour)	1.52	1.52

1) Harvesters' share in bawon system.
2) Assume 3.9t/ha of average paddy yield.
3) Market wage rate for dry season land preparation in paddy equivalent.
Source: Kikuchi [30, 301].

reduced to 1/6, and further to 1/7 after the second one in the early 1970s. In around 1980, the majority of farmers adopted a harvesters' share of 1/10.

Reductions of harvesters' share does not mean declines in wage paid to harvesters. On the contrary, actual payments to harvesters have increased owing to the rapid increase in rice yield per hectare. It could be considered that the successive reductions in harvesters' share occurred to reduce a gap between harvesters' wage and marginal productivity of their labor emerged due to the increase in rice yield under a harvesters' share. The results of estimation of imputed wage rates for harvesting labor in Table 9 strongly support this postulate. Under the most prevalent harvesters' share of 1/10 in the late 1970s, the imputed wage rate is equated precisely with its opportunity cost[32]. Such a result suggests a good performance of the rural labor market in this area.

West Sumatra

Among the changes in rice farming in West Sumatra observed in the previous chapters, important changes in relation to the labor market are; the irrigation development in the 1960s and the resulting increase in multiple-cropping ratio of lowland paddy, the increase in land productivity due to the successful introduction of the new seed-fertilizer technology since the late 1960s, the mechanization in post harvest activities in the late 1970s, and the out-migration tradition of Minangkabau and recent development in the non-farm employment opportunities.

Of these changes, the first two are the factors that have brought about increases in labor demand in agriculture, just as in West Java. For instance, the introduction of MV technology worked to increase the demand for labor as shown in Table 10.

The last point above is related to the rural labor supply. Since long ago, the tradition of out-migration in Minangkabau called *murantau* has been famous. Many reasons that gave rise to this out-migration tradition have been pointed out; increasing population pressure, liberation from the strain in the matrilineal society bound by the strict customary law (*adat*), enterprising spirit of Minangkabau, occupational training, and etc. Whatever the reasons, this tradition still firmly subsists and many people migrate out for pursuing job opportunities outside. The extent of out-migration is such that, in the case of a rice village in Agam Regency, 34 percent of the village population are working outside (Iwasaki [23, 8]).

Such a deep-rooted tradition of out-migration would inevitably give an

adverse impact on the rural labor supply. Particularly crucial to the rural labor force in this area is a fact that the majority of out-migrating population is male at the productive age of 20 to 40 years old. In fact, labor shortage is the problem cited most often by the rice farmers in West Sumatra, and it is easy to find out apparent symptoms of labor shortage, such as abandonment of upland rice cultivation, many paddy fields left idle, and a lot of empty houses in the villages (Yonekura [45, 45–46],

Table 10. Labor use in rice production, TV vs. MV, West Sumatra, 1969 dry season

	Padang Pariaman		Tanah Datar	
	TV	MV	TV	MV
Number of samples	3	57	9	46
Average size of farmers(ha)	0.62	0.69	0.44	0.58
Labor input(days/ha)	74.6	128.2	92.9	133.9
Draft animal input(days/ha)	-	21.8	28.8	44.9

Sourse: Nurdin [34, 43-46], quoted in Yonekura [45, 51].

Table 11. Changes in rice yield, paddy price, wage rate and harvesters' share in West Sumatra, 1971 to 1984

	1971	1984	% change
Rice yield(t/ha)	3.0	4.0	33
Paddy price(Rp/kg)	24[1]	170	608
Nominal wage rate[2](Rp/day)	225	2250	900
Real wage rate[3](kg/day)	9.4	13.2	40
Harvesters' share[4](%):			
Cutting	-	6	-
Threshing	-	7	-
Winnowing	-	3	-
Total	12	16	33

1) Estimated assuming a ratio of paddy price recieved by farmers to retail price of rice of 53% that prevailed in 1984.
2) Wage rate for land preparation.
3) Nominal price divided by paddy price.
4) Typical shares in the region. In case machines are used for threshing and/or winnowing, the shares include payments to the machines.
Source: Figures for 1971 are estimated from Kahn [25, 69-70].

Iwasaki [23, 5]).

Such situations in demand and supply of labor has resulted in a rise in the agricultural wage rate in West Sumatra (Table 11). From 1971 to 1984, the real wage rate in agriculture rose by 40 percent. Unlike the case of the West Java village studied above, even the harvesters' shares, though including payments to machines, have increased[83]. It is this labor shortage manifested by the rise in wage rate that has induced the post harvest mechanization in West Sumatra. It should be remembered that the major reasons of *lumbo* and thresher adoption raised by farmers are 'shortage of labor' and 'quickness of operation'. As shown in Table 12, the effects of the post harvest mechanization in saving labor use is clear. The adoption of *lumbo* reduces the labor requirement for winnowing by 5 mandays per hectare and that of thresher does by about 15 mandays per hectare for

Table. 12 Labor use per hectare in harvesting by type of technology, West Sumatra, 1984[1]

Cutting Threshing Winnowing	Technology		
	I Sickle Foot Wind	II Sickle Beating Lumbo	III Sickle Thresher Lumbo
Cutting:			
Family	1.6(9)	0.3(2)	0.2(1)
Hired	17.0(91)	18.5(98)	18.7(99)
Total	18.6(100)	18.8(100)	18.9(100)
Threshing:			
Family	0.3(3)	0.3(2)	-(-)
Hired	20.2(97)	16.9(98)	4.0(100)
Total	20.5(100)	17.2(100)	4.0(100)
Winnowing:			
Family	-(-)	-(-)	-(-)
Hired	9.0(100)	4.0(100)	4.0(100)
Total	9.0(100)	4.0(100)	4.0(100)
Total:			
Family	1.9(4)	0.6(2)	0.2(1)
Hired	46.2(96)	39.4(98)	26.7(99)
Total	48.1(100)	40.0(100)	26.9(100)

1) Figures inside parentheses are percentages.

Table 13 Imputed wage rate for harvesting labor in West Sumatra, 1971 and 1984

	Technology	
	I Sickle Foot Wind	III Sickle Thresher Lumbo
1971		
Labor input[1](days/ha)(1)	40	-
Harvesters' share[2](kg/ha)(2)	360	-
Imputed wage rate(kg/day)(2)/(1)	9.0	-
Market wage rate[3](kg/day)	9.4	-
1984		
Labor input(days/ha)		
Cutting	21	21
Threshing	23	4
Winnowing	10	4
Total(1)	54	29
Harvesters' share[4](kg/ha)(2)	640	373
Imputed wage rate(kg/ha)(2)/(1)	11.8	12.9
Market wage rate[3](kg/ha)	13.2	13.2

1) Includes cutting, threshing and winnowing.
2) Paddy yield=3.0t/ha, share=12%.
3) Market wage rate for land preparation, in paddy equivalent.
4) Paddy yield=4.0t/ha, share=16%. When a thresher and/or a lumbo are used, payments for the capital service of these machines are 2/3 of the respective shares.

threshing. Similar to the West Jave case, this substitution of fixed capital for labor in the post harvesting process has been greatly facilitated by the emergence of rental markets both for the *lumbo* and the thresher.

So far as these markets, the labor and the capital rental markets, function well, this substitution of fixed capital for labor is economically desirable. For West Sumatra too, the information is too limited to check the workings of the factor markets. A circumstantial evidence, however, is presented in Table 13.

As explained in the previous chapter, there co-exist in this area three systems in terms of post harvest technology adopted; foot threshing-wind winnowing, beating threshing-*lumbo*, and thresher-*lumbo*. The traditional

system before the mechanization was foot threshing-wind winnowing, and the latest system is thresher-*lumbo*. In Table 13, the imputed wage rates of harvesters are estimated for these two systems, taking changes in harvesters' shares into account. Before the mechanization, the imputed wage rate under the traditional system was almost in an equilibrium with the market wage rate. In 1984 when the market wage rate rose, the imputed wage rate under the traditional system was lower than the market wage rate, while that under the latest system was almost equal to it. These results suggest that a disequilibrium emerged in the labor market has been well adjusted so as to restore the equilibrium through changes in the harvesters' shares and through the labor-capital substitution.

(2) Consequences of mechanization

How about consequences of the mechanization upon income distribution in the rural areas? It is often voiced that labor replacing mechanization in an area where labor is relatively abundant would have an adverse impact on the welfare of the rural poor whose income heavily depends on hired labor works in farming. If such mechanization occurs with a condition in the labor market such that an increase in the supply exceeds that in the demand, its impact on welfare of the rural poor could be disastrous. However, as we have just observed, the mechanization in West Sumatra and West Java was both triggered by increasing scarcity of labor manifested in the rising trend in the real wage rate. Under such a condition in the labor markets, what are consequences of the mechanization?

Although available evidences in this respect are not sufficient yet, they seem to reveal that the impact of mechanization on income distribution in rice production has not been so adverse for the rural poor.

For example, Duff [13] reports that the tractorization in West Java has not brought about a more unfavorable income distribution for the labor (Figure 3). The factor share of capital increases from non-mechanized to mechanized farms because of the tractorization. Of particular interest is that the share of labor is slightly higher for mechanized than for non-mechanized farms. In contrast, the share of land is lower for mechanized farms. Since the rice yield does not show any significant difference between the two types of farms, these facts mean that the owners of labor resource are not worse off relative to those of land resource. More directly, the share of output obtained by hired laborers is significantly higher for mechanized farms. This may be due partly to the fact that the mechanized farms are relatively large farms who depend on hired labor more heavily. Whatever

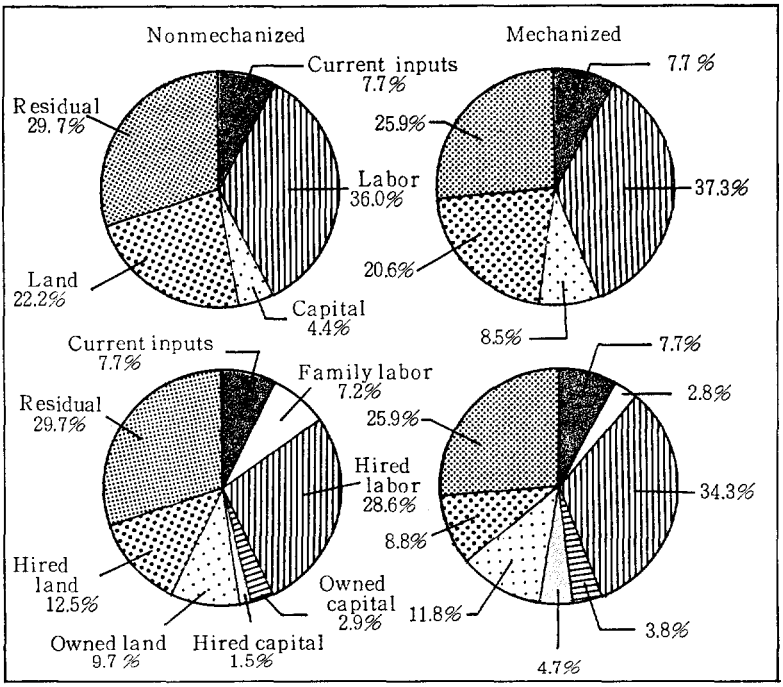

Figure 3. Comparison of factor shares in rice production between mechanized and non-mechanized farms in selected villages in Subang and Indramayu, West Java, 1979-1980 wet season

Source: Duff [13, 74].

the reason, it is clear that the tractorization in this area does not work against labor and hired laborers, if not saying their welfare is appreciably better off[34].

For the case of West Sumatra, similar estimates are not available. Deuster [12], studying changes in rice farming in a West Sumatra village during the 1970s, finds that income distribution did not change appreciably in this decade. His study period does not cover the recent years of thresher adoption, but it does the years after the introduction of *lumbo*. Table 14 provides another side evidence. Fifty percent of our farm laborer samples reported that employment opportunities in harvesting activities had decreased, while the other 50 percent did either constant or increase in the opportuni-

Table. 14 Changes in employment opportunities in rice harvesting and other activities as reported by sample farm laborer households in West Sumatra, 1984

	Agam	Padang Pariaman	Sawah Lunto Sijunjung	Total
Percentage of households employed in harvesting activities:				
1. Household head	90	75	73	80
2. Family members	20	25	50	33
Changes in employment opportunities in: (%)				
1. Harvesting activities				
a. Increased	35	0	14	19
b. Constant	25	17	45	31
c. Decreased	40	83	41	50
2. Other alternative opportunities				
a. Available	100	70	78	82
b. Not available	0	30	22	18

ties. More importantly, the majority answered that alternative employment opportunities were available other than works in harvesting activities. Plentiful employment opportunities with a rising real wage rate seem to indicate that the income position of those depending on labor works has not been worse off.

Altogether, unlike the popular belief, the agricultural mechanization in these two regions has not been associated with apparent impoverishment of the landless and near-landless households in the rural areas.

(3) Why post havest machanization in West Sumatra?

Finally, let us briefiy touch on a question: why the direction of mechanization differs between West Sumatra and West Java, the post harvest mechanization in the former and the tractorization in the latter, in spite of the fact that a rising trend in the rural wage, or increasing scarcity of labor, is the basic inducement to mechanization commonly in both regions? The answer to this question seems to be sought in environmental as well as cultural differences between the regions.

As already explained, the need of timely land preparation, or the need to shorten the time for it, is high in the areas of West Java where the tractorization has been significant. This is due to the tight water distribu-

tion schedule of Jatiluhur Irrigation System. Having little rain in the dry season, it is always better for farmers to plant rice as early as possible to avoid possible drought. Without irrigation water, it is totally impossible to grow rice in the dry season in this area. Overlapping of harvesting and land preparation of the following season creates labor shortage in both the wet and the dry seasons, further facilitating the need of timely operations. Furthermore, the ecological condition of completely flat plain with rice double cropping in West Java makes it difficult to raise water buffalos. In contrast, in West Sumatra, there is some rainfall even in the dry season so that the need of speedy land preparation is not so urgent as compared to West Java.

The labor peak for harvesting and land preparation could be dealt with not only by tractorization but by post harvest mechanization. The post harvest mechanization in West Java, however, seems to have been checked by the deep-rooted tradition of *bawon* harvesting. In this system, harvesting is considered as a work to be carried out by hired labor and three operations in harvesting and post harvesting process are firmly combined for obtaining the *bawon* share. Under such a tradition, it is not without social cost to introduce a thresher which may separate the operations and break the claim of harvesters to get the whole share. In contrast, three operations in harvesting process have long been considered as carried out separately by different groups of hired laborers in West Sumatra.

These differences in ecological conditions and in cultural traditions would explain, to a certain extent, the different direction of mechanization in the two regions. However, how far these differences continue to check in the future the mechanization not adopted now is uncertain. Rather, the experiences in the two regions seem to suggest that the other mechanization is easily forthcoming in each region if scarcity of labor continues to increase.

5. Concluding Remarks

We have examined the process of agricultural mechanization in West Sumatra in comparison with that in West Java. In the former region the post harvest mechanization has been going on rapidly, and in the latter region the mechanization of land preparation by the use of hand tractor has almost perfectly kicked out the traditional animal cultivation within a several year period. Though different in the direction due to different ecological and cultural conditions, the inducement to mechanization commonly identified

for the two regions was the increasing relative scarcity of labor. In both regions, the real wage rate in agriculture has risen by 40 to 50 percent in the last decade or so. Responsible for this rise in agricultural wages were; technological changes in agriculture that had increased labor demand, and development of the non-farm sector that had exerted demand pressure on the rural labor markets.

Contrary to the popular belief, available data indicate that the mechanization has not had an adverse impact on the income position of the rural poor. As far as the mechanization is the capital-labor substitution process induced by rises in wage rate relative to price of capital, there is little economic ground to expect the popular belief be materialized. Well working labor and capital rental markets in the rural areas facilitated this substitution process. Mechanization is not always an evil even in a country like Indonesia where labor is relatively abundant. It is blessing that heavy painful labor works are relieved and replaced by easier works with machines to the extent economically justified.

It must be remarked, however, that the above conclusion implies neither that mechanization should always be promoted in any circumstance nor that the mechanization in West Sumatra and West Java has been fully desirable in the social point of view. It only states that the labor-capital substitution through the mechanization can be justified with prices prevailing at the level of rural markets. Government interventions in the capital market are often prevalent in developing countries. In fact, the price of hand tractors in Indonesia is artificially lowered through over-valuation of the local currency and low import tarifis, and prices of gasoline and oil are also heavily subsidized (Nehen and Wills [33, 139–145]). These market distortions create a gap between the private and the social costs of the mechanization and lead to premature mechanization, resulting in curtailment of productive employment opportunities otherwise available to the rural poor and in wastes of capital resources most precious to the developing countries[35]. If performances of the labor and capital markets are high as pointed out in this paper, such interventions to markets should be avoided as much as possible.

Notes

1) This study is an output of a research project, "Appropriate Technology and Its Diffusion for Agricultural Development in the Third World", supported by the Agency for Science and Technology of Japan. The major part of the study was carried out during the stay of the senior author as a visiting specialist at the National Research Institute of Agricultural Economics for October 28–

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2) As to agricultural mechanization in Asian developing countries in general and in Indonesia in particular, see papers in the following books: Barker and Herdt [3, 108-122], Asian Productivity Organization [2], International Rice Research Institute [20], [21], [22]. Also see Binswanger [5].

3) Irrigation and seed-fertilizer technology are examples of this type of technology. See Johnston and Cownie [24], Lipton [32] and Hayami and Kikuchi [17]. On the concept of 'appropriate technology," see, for example, White [41].

4) For details of this survey, see Reddy *et al.* [36].

5) Non-farmer households include some non-agricultural households living in rural villages.

6) In 11 West Java rice villages studied by Collier *et al.* [10], the average share of landless laborer households in total households is as high as 54 percent.

7) For the structure of Minangkabau peasant society, see Kahn [25, 39-57] and Yonekura [43, 198-206].

8) For West Sumatra, Yonekura [45] and Iwasaki [23]; for West Java, Hayami and Kikuchi [17, 171-208] and Fujimoto [14].

9) Yonekura [45] and Iwasaki [23]. An increase in wage rate in rural areas due to rapid development of the non-farm sector has also been observed in West Java. See, for instance, Collier *et al.* [10, 40-48].

10) Samples in our survey, the data of which are used in this paper, are drawn from six rice villages located in three regencies in West Sumatra; Agam, Padang Pariaman and Sawah Lunto Sijunjung. The first belongs to the *Darek* and the other two to the *Rantau*.

11) The increase in rice yield per hectare in the 1970s was higher for the total than for lowland paddy. This is due to a fact that the area planted with upland rice, yield of which is much lower than lowland paddy, decreased dramatically in this period. It is said that the marginal production of rice in upland and shifting cultivation was abandoned due to labor shortage that became serious in this period (Yonekura [45]).

12) This mechanization of rice milling in Indonesia, especially in Java, was remarkable in its swiftness and thoroughness. Manual milling was replaced by machine milling within a few years in many rice villages in Java, and it is said that 120 million women work days were lost by this almost overnight switch to machine milling, giving adverse effects on the welfare of rural poor (Timmer [39] and Collier *et al.* [9]).

13) Tractorization of rice farming in West Java has attracted attention of agricultural economists since the mid-1970s, and studied intensively since then. For example, Sinaga [38], Kasryno *et al.* [29], Lingerd and Bagyo [31], Nehen and Wills [33], and Inamoto [19]. These studies reveal that the tractorization in West Java has a strong regional bias toward the completely flat coastal plain along the Java Sea.

14) Yonekura [45, 52-53]. A *kongsi* group usually contracts for manual land

preparation.

15) Exceptions for this occur only for farmers who own tractors. The number of such farmers is very limited however even in areas where the tractor land preparation diffused almost 100 percent. This is due partly to the fact that some tractors are owned by non-farmers who make tractor custom hiring into a business. More important is that the efficiency of tractor land preparation is much higher than that of animal. The former is 3-6 times as efficient as the latter per unit of time for plowing/harrowing. Moreover, while a draft animal can work, at maximum, 8 hours a day, working hours per day of a tractor can reach 24 hours. As a matter of fact, overnight land preparation by tractor is very popular in some parts of West Java where tractorization has been on progress. These two sources combined, the effciency of tractor land preparation is 10-20 times as high as that of animal land preparation. See Hurun [18].

16) Kasryno *et al.* [29, 73-83]. Remarkable in this permanent labor system is that this arrangement often accompanies such services from employer-farmers to employee-laborers as consumption loan and lending of farm land under share cropping arrangement. It is reported by Kasryno *et al.* [29, 81] that the income of permanent laborer households is higher by 30 percent than other landless laborer and near-landless households. Hart [15, 170-186], referring to this evidence, argues that 'differentiation' or 'segmentation' of rural labor markets in Java has been in progress. It should be noted, however, that this type of permanent labor system is found out in areas where agricultural wage rates are rising (Binswanger and Rosenzweig [6, 24-25]).

17) The division of labor by sex was rather clear for rice cutting; *ani-ani* exclusively by women and sickle mostly by men.

18) The changes in harvesting systems in Java have attracted serious attention of scholars and administrators concerned with rural issues since the early 1970s, partly because their changes would have had serious implications on the welfare of the rural poor. See Collier *et al.* [8], Hayami and Hafid [16], and Hayami and Kikuchi [17].

19) This type of harvesting system is found throughout South and Southeast Asia. For instance, see Kikuchi [30], Clay [7], and Ohno [35].

20) *Ceblkan* System is an old system in West Java (Hayami and Hafid [16, 97-99]), and similar systems called *kedokan* or *ngepak ngedok* with a long history are found in other parts in Java (van der Kolff [40] and Kano [26]).

21) *Tebasan* is an old system recorded since the last century. However, until recently it was adopted primarily for cash crops such as sugar cane and fruits but was not common for rice (Collier *et al.* [8], Wiradi [42], and Hayami and Hafid [16]). Collier *et al.* [8] argued that the shift from *bawon* to *tebasan* excluded a large number of laborers from rice harvesting, resulted in reductions of wages for harvesters through a shift to the day labor system, and brought about greater misery to the rural poor. Stimulated by their study, many researches have been conducted on this issue, clarifying that the shift to *tebasan* itself does not necessarily mean a reduction of employment opportunities in rice harvesting (Hayami and Hafid [16]), that wages paid by *penebas* are more often wages in kind proportional to output than daily cash wages (Hayami and Hafid [16]), that in some cases the *penebas* maintains the *bawon* frame-

work for harvesters (Kano [27, 112-120]), and that regional distribution of *tebasan* has an inverse relation to that of *ceblokan* (Wiradi [42, 53-57] and Hayami and Hafid [16, 97-101]).

22) Other assumptions in the breakeven point analysis are; 1) three year usable life, 2) 10.5 percent of interest rate, 3) 2 percent of custom charge, 4) 2 percent of product price for maintenance cost per 100 hours, and 5) 1/3 of custom share for operators' wage. The working capacity of *lumbo* is, on the average, about 270 kg/hour, though it varies according not only to the type used but to the speed at which the blower is rotated.

23) These workshops are long established ones producing numerous metal products such as iron fence, rail, household utensil, and car repair services.

24) Main sources of funds for purchasing the thresher raised by the sample owners are sale of land/cattle and saving from *lumbo* operation. Loan users are rather limited in number; 6 percent for bank loan and 1 percent for loan from neighbors.

25) Assumptions for this breakeven point analysis are; 1) Rp. 650,000 of acquisition price, 2) four year of usable life, 3) 10.5 percent of interest rate, 4) 7 percent of custom charge, 5) 1/3 of custom charge for operators' wage, 6) 1.5 percent of acquisition price for maintenance cost per 100 hours, 7) (1 liter gasoline+2.5 liter oil)/hour for operating the machine with prices of Rp. 370/liter and Rp. 1, 750/liter respectively, and 8) 350 kilograms of paddy/hour of working capacity.

26) Some workshop owners who produce threshers also engage in the thresher custom hiring business.

27) For more details on this village, see Hayami and Kikuchi [17, 195-207] and Kasryno *et al.* [29].

28) Among the technological changes listed here, the tractorization has a significant impact neither on rice yield per crop nor on cropping intensity. Nehen and Wills [33, 59-87] and Saefudin *et al.* [37].

29) In 1968-71, the Jatiluhur Irrigation System was still under construction but starting a partial supply of water to the service areas. As the result the cropping intensity in this village already increased to 1.5.

30) Colter [11] found that 30-40 percent of farm labor works in this area was carried out by migrant laborers in 1980.

31) The rental rate of water buffalo has also risen sharply. This is due mainly to an increase in the cost of raising buffalo, the major compoent of which is the labor cost.

32) The market wage rate chosen for comparison with the imputed wage rates in Table 9 is for land preparation. This is partly because harvesting in this area is no longer a female activity after the switch from the *ani-ani* to the sickle and partly because the competition in labor use due to the tight water scheduling is especially stringent between the wet season harvesting and the dry season land preparation. Before the tractorization, a sort of minimum tillage method called *walik jerami* was a common practice to avoid this competition.

33) Yonekura [45, 55] reports that in a village near Bukittinggi City in Agam the harvesters' share was raised from 10 to 15 percent in 1980.

34) Also see Kasryno *et al.* [29, 99].

35) Premature tractorization due to government inteventions to the capital markets is popular among Asian developing countries. See Binswanger [5] and Ahmed [1].

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インドネシアの農業機械化に関するノート
——西スマトラと西ジャワの比較——

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アジアの開発途上国における人口増加率は未だ高く，非農業部門の一定の発展を前提としても，増加人口のかなりの部分を農業部門で雇用していく必要が今後も長期にわたって続くと予測される。かかる状況下において，これら開発途上諸国の農業における労働代替的な機械化の進展は，農業における雇用労働から得られる所得にその生計を大きく依存しているこれら諸国農村の貧困層（土地無し労働者・零細小農）の雇用機会を奪い，農村部における所得分配の不平等化をもたらすものとして，従来一般的に望ましくないものと考えられてきている。にもかかわらず，農業の機械化は，これら諸国の多くの農業地帯で進行している。1)これら諸国の機械化はいかなる要因によって誘発されているのか。2)それは途上国農村部にいかなる経済的帰結をもたらしているのか。3)これら諸国における農業機械化は従来考えられてきたように「非適正技術」であるのか。本稿の目的は，アジアの開発途上国の多くで農業部門および非農業部門の発展が顕著なものとなった1970年代から現段階までを視野に入れつつ，これらの問題に対する一定の解答を得ることにある。

西スマトラの脱穀機化と西ジャワの耕耘機化を事例としてなされた本稿の分析の主要な結論は以下の通り。1)これらの機械化を誘発した共通要因は，灌漑改善による水稲2期作化・「緑の革命」技術の導入普及という稲作における技術変化ならびに非農業部門の発展により農村労働市場において労働需要が増加し労働の希少性が高まったことにある。換言すれば，これらの機械化は市場における相対価格の変化に伴う正常な資本と労働の代替過程であった。この代替過程を円滑なものにしたのは，良く機能する労働市場と資本用役市場の存在である。2)これら機械化が，必ずしも農村における所得分配の不平等化を帰結していない点でも両地域は共通している。3)労賃の相対的騰貴という条件下で生じる限り，機械化は一概に「非適正技術」とは言いえない。

以上の結論は，農村レベルの市場分析から導出されるものであり，インドネシアにおいても存在する通貨の過大評価，資本財への低利金融・必要以上に低い関税率といった，資本市場における歪みを正当化するものではない。これらの歪みは，機械化を確実に社会的に望ましい水準以上に押し進め，農業雇用機会の必要以上の削減・資本の浪費・農村部における所得分配の不平等化等社会的に望ましくない事態を結果するであろう。