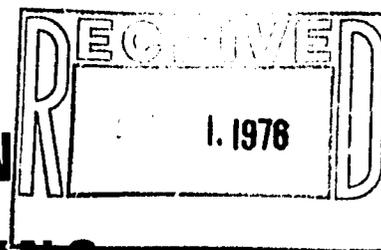


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9. ABSTRACT This paper describes developments in rice farming in Japan from World War II to the early 1970s. Land reform after WWII distributed ownership of farm lands to family units. In 1970, 79 percent of the farm households in Japan owned 90 percent of the total cultivated land. As of 1971, 82 percent of the 5.2 million farm families were growing rice on farms that averaged 1.06 hectares (2.6 acres) in sites. The farm work has been gradually mechanized. In 1945, only 8,000 power tillers were being used in Japan; in 1972, 3.5 million of them were in use. The use of power threshers and power sprayers has similarly increased. Those labor-saving developments, along with the desire of farm-household members to increase their income, have significantly altered the percentage of farm families who derive their income solely from the family farm. In 1950, this was 50 percent of all farm families; in 1972, this was 14.4 percent of all farm families. One result of this is that Japanese agriculture has become more specialized in rice production. Since 1960, domestic production of wheat, soybeans, and feed grains (corn and sorghum) has decreased, relative to the amounts imported. An estimated 50 percent of the total food supply in Japan is now imported.		
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THE CHANGING STRUCTURE OF AGRICULTURE IN JAPAN:  
EFFECTS ON RICE FARMING\*

Dr. Motosuke Kaihara\*\*

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THE CHANGING STRUCTURE OF AGRICULTURE IN JAPAN:  
EFFECTS ON RICE FARMING

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Introduction

There have been some statistics on and statistical analyses of Japanese agricultural development accumulated as part of a framework for study of the overall economic development of Japan. However, few have been informed as to the realities of the role of farmers in the development process. In this paper I would like to present briefly the recent developments in rice farming which clearly characterize the pattern of Japanese agricultural development--those involving changes in land tenure patterns and group action by farmers.

The Significance of Rice Farming

It is no exaggeration to say that the history of Japanese agriculture began with the introduction of rice cultivation. Most farm people have lived off the paddy fields: rice is their staple food. Until recently, rice was the only substantial food in the Japanese diet and it has always been regarded as a superior good.

Rice farming is still the basis of domestic agriculture in Japan and is sure to remain important in the future. In 1970, 59 percent of the total cultivable land in Japan was paddy field. (See Fig. 1.) From 1966 to 1970 rice represented 43 percent of the aggregated value of agricultural production at the

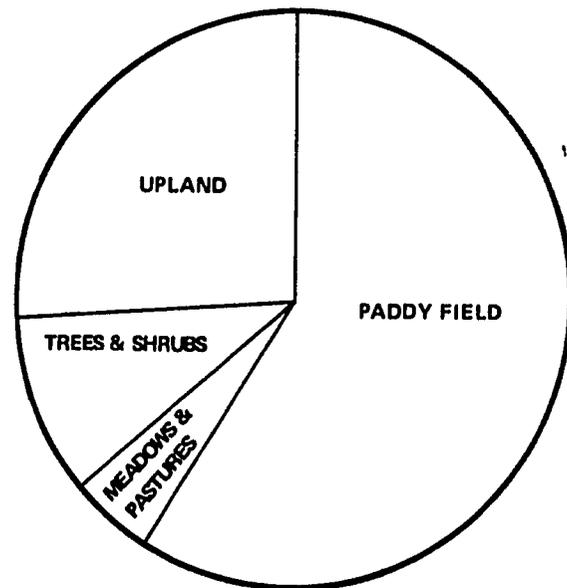


Fig. 1: Utilization of cultivable land in Japan, 1970.

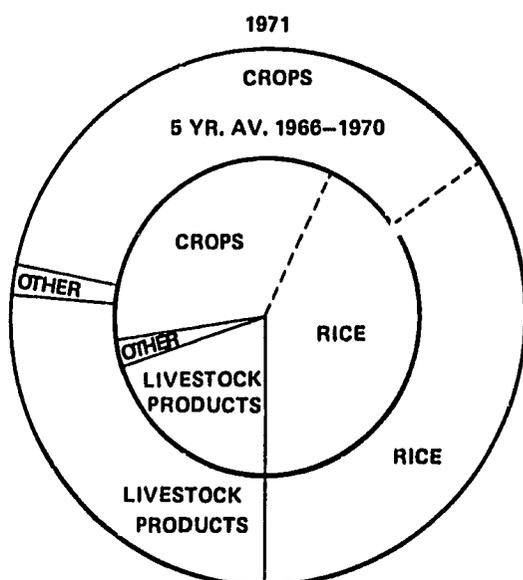


Fig. 2: Share in agricultural product in Japan, 1966-70 and 1971, at current prices, by type of product.

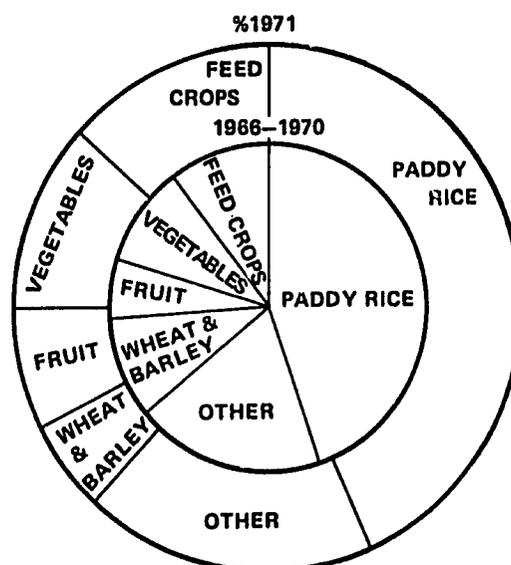


Fig. 3: Change in crop acreage in Japan, 1966-70 (= 100) and 1971 (= 91.4), by type of crop.

current price. (See Fig. 2.) During the same period, 45 percent of the aggregated acreage planted was rice. (See Fig. 3.)

In 1960, 90 percent of the aggregated value at the current price of all food supplied in Japan was derived from domestic production and only 10 percent from imports. (See Fig. 4.) However, food imports increased year by year until in 1971 the share of domestic production had decreased to 72 percent while 28 percent was imported. At present, it is estimated that food imports account for more than 50 percent of total food supply in terms of nutritional value, especially when evaluated in calories.

Since 1960, the relative amount of the domestic supply as a percentage of the total supply decreased remarkably for wheat, barley, soybeans, and feedgrains. Domestic supply of wheat as a percentage of total supply decreased from 39 percent in 1960 to only 9 percent in 1970. For soybeans it was 28 percent in 1960, but only 4 percent in 1970. For feedgrains (mostly corn and sorghum) the figures are converted to equivalent of total digestible nutrients. On this basis the domestic supply was 67 percent of total supply in 1960, but only 33 percent in 1970.

Food imports as a percentage of total imports are increasing; by 1970 food imports constituted 13.6 percent of all imports into Japan.

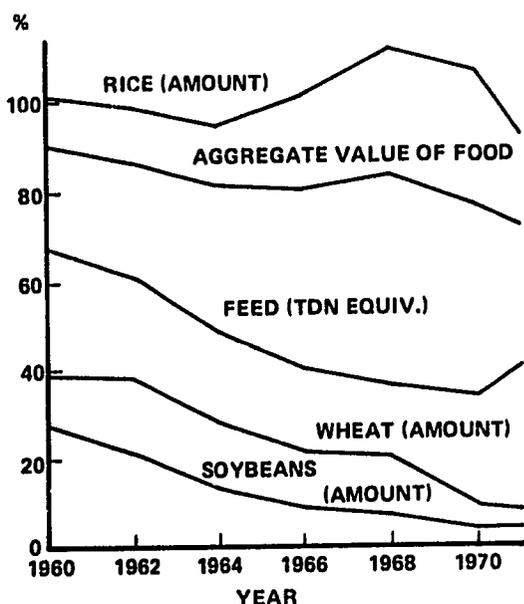


Fig. 4: Domestic supply of agricultural products as percent of total supply in Japan, 1960-70.

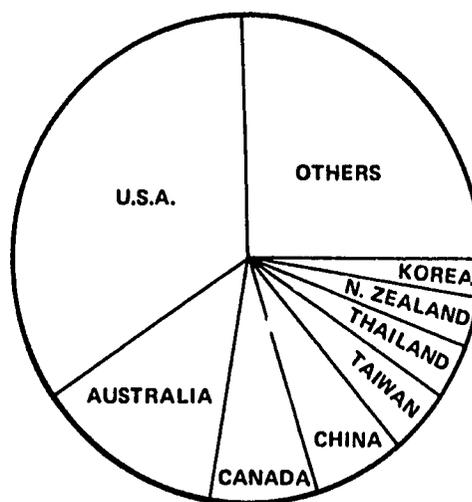


Fig. 5: Sources of agricultural products imported into Japan in 1972 by value.

The United States is a major source of agricultural products imported into Japan, providing 38.3 percent of all such products in 1970 and 33.4 percent in 1972. (See Fig. 5.) In 1972, 92 percent of the soybeans, 58 percent of the feedgrains, and 49 percent of the wheat imported into Japan were from the United States.<sup>1</sup>

Unlike other grains, since 1969 rice has been supplied nearly 100 percent from domestic production as the result of a continuing

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1. Japan, in general, is the leading overseas market for total and farm product exports of the United States.

In 1970, U.S. exports to Japan totaled \$4.6 billion. Agricultural products accounted for \$1.2 billion or 17 percent of farm product exports to all destinations. Soybeans, of course, were the leading item exported to Japan: 1970 shipments totaled 3 million tons, valued at \$305 million, equivalent to 25 percent of all U.S. soybean exports. Shipments of corn worth \$235 million amounted to 29 percent of the total U.S. corn exports to all destinations. Wheat shipments to Japan, worth \$157 million, amounted to 16 percent of all U.S. wheat exports in 1970. Japanese Overseas Aid and Investments: Their Potential Effects on World and U.S. Farm Exports, Foreign Agricultural Economic Report no. 81 (U.S.D.A. ERS, 1972).

program of rice commodity management by the government under the Staple Food Management Law.

Rice consumption per capita in Japan has tended to decrease since 1960. More protein and fat are eaten per capita in what are considered to be improvements in food consumption patterns, although the nutritional quality of the Japanese diet is not adequate when compared with that of Western developed countries. Rice is still very important in Japan, both as a staple food and as the major basis of farming.

#### Characteristics of Farming in Japan

Before turning to developments in rice cultivation techniques, it is appropriate to summarize briefly some characteristics of farming in Japan.

1) Family farm. The unit of farm operation in Japan is mostly the family farm. The number in 1971 was estimated to be 5,261,000.<sup>2</sup> There are a few corporate farms--3,069, less than .06 percent of all farms--and some of these are operated by people who are related to each other.

2) Crop production. As shown in Fig. 2, 76.8 percent of the value of agricultural production, using a five-year average for the period 1966-1970, was from crop production. Sericulture accounted for only 2.7 percent and livestock production for 20.5 percent, which was closely related to the large amounts of imported feed. In 1971, 82.6 percent of all the farm-households produced rice.

3) Small-scale cultivation. In 1970 the average cultivated area per farm-household was 1.06 has. (2.6 acres). In Hokkaido it was 5.95 has. (14.7 acres), and in all other areas, excluding Hokkaido, it was 0.93 ha. (2.3 acres). While there are some differences in the size of farms with respect to location, and especially climate and urbanization,

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2. The estimate came from the 1970 agricultural census and a sample survey for the interval year. Farm-households in the agricultural census in Japan have been defined as: 1) households with cultivated land of 0.1 ha. (equal to 0.247 acres) or more land in Hokkaido and 13 other prefectures in the northern part of Japan (where in general it is cool) and 0.05 ha. (equal to 0.12355 acres) or more land in the other 32 prefectures; or 2) households which earned ¥50,000 or more by selling agricultural products from their own farm in the previous year even if the cultivated land of the household is smaller than the limit. This last criterion rose from ¥20,000 or more in 1955 and 1960, and ¥10,000 or more in 1950.

for many years no significant change has been made in the area of cultivated land per farm-household.<sup>3</sup>

4) Owner-operated farm. At the present time, agriculture in Japan is carried out substantially under an owner-operated system of farming. Of course, this is due to the agricultural institutions resulting from the land reform after World War II<sup>4</sup> and the Agricultural Land Law. In 1970, 79.4 percent of the farm households in Japan owned 90 percent or more of the total cultivated land, as is shown in Table 1.

Table 1. Tenure Status of Farm Households<sup>a</sup> in Japan, 1970  
(Number in Thousands)

	<u>Number</u>	<u>Percent</u>
Total number of farm households	5,342	100.0
Owner-operated	4,241	79.4
Owner-tenant	852	15.9
Tenant-owner	150	2.8
Tenant	85	1.6
Exceptional farms <sup>b</sup>	13	0.2

<sup>a</sup>Tenure of farm households is based on the ratio of cultivated land owned to the total operating cultivated land as follows:

Owner-operated	90 percent or more of cultivated land
Owner-tenant	50-89 percent
Tenant-owner	10-49 percent
Tenant	less than 10 percent.

<sup>b</sup>The household with cultivated land of less than 0.099 hectares or 0.049 hectares or with no land, however, was counted as a farm household only if the total sales of farm products for the year amounted to ¥50,000 or more (for 1950, ¥10,000 or more; for 1955 and 1960, ¥20,000 or more; for 1965, ¥30,000 or more).

3. The estimated area of cultivated land per farm-household increased slightly in 1972 to 1.1 has. Hokkaido's average was 6.7 has., and that of the other areas was 0.9 ha. The differences derived from what happened to land which farmers ceased to cultivate: in Hokkaido the land was integrated to other farms; in other areas the land was either turned back to such nonfarm uses as forest, etc., or, in the mountain areas, continuously cultivated by the family members as a part-time farm-household.

4. Many references on the land reform and its effects are available. Two points should be noted here. 1) The land reform greatly influenced

5) Part-time farming. Table 2 shows the numbers of farm households classified by degree of farming engagement of family members in the farm household. Since 1960 the relative number of part-time farm-households increased. Furthermore, the percentage of farm-households in which family members work more on other jobs than their own farming has increased.

Table 2. Number of Farm-Households Classified  
by Degree of Farming Engagement

Year	Total	Full-Time Farms	Total	Part-Time Farms	
				Mainly Farming	Mainly Other Jobs
(a) Number in thousands					
1955	6,043	2,106	3,937	2,274	1,663
1960	6,057	2,078	3,978	2,036	1,942
1965	5,665	1,219	4,446	2,081	2,365
1970	5,342	831	4,510	1,802	2,709
1971	5,261	798	4,463	1,567	2,896
1972	5,170	743	4,427	1,404	3,023
(b) Percentage					
1955	100.0	34.8	65.2	37.7	27.5
1960	100.0	34.3	65.7	33.7	32.0
1965	100.0	21.5	78.5	36.7	41.8
1970	100.0	15.6	84.4	33.7	50.7
1971	100.0	15.2	84.8	29.8	55.0
1972	100.0	14.4	85.6	27.1	58.5

Part-time farm-households are divided by Japanese statisticians into two categories: Type I, households in which farm income exceeds

agriculture and the rural economy in Japan. It is regarded as having set the basic conditions for further economic development, so that food production, labor supply, and purchasing power all increased. The significance of the land reform can be said not to be only a mere transfer of title but also an improvement of the socio-economic structure in rural areas: the tenant became an established citizen who had equal opportunity. 2) At present the reform has come under criticism with regard to agricultural productivity, because provisions of the reform constitute an obstacle to the creation of larger-scale mechanized farming. But this is an organizational problem and certainly depends upon the preference of rural people. I do not think that the owner-operated farm in Japan is an obstacle to further development.

off-farm earnings; Type II, households in which the reverse is true. Table 3 shows what has happened to full- and part-time rural households since 1950. Most noticeable is the decrease in full-time farm-households (from 50 percent of all farm-households in 1950 to 14.4 percent in 1972), and the increase in Type II part-time households (from 21.6 percent of all part-time farm-households in 1950 to 58.5 percent in 1972). Movement out of full-time farming has been considerable.

Table 3. Number of Full- and Part-Time Farm-Households  
1,000/(%)

Year	Total No. of Farm-Households	No. of Full-Time Farm-Households	No. of Total Part-Time Farm-Households	of which	
				Type I	Type II
1950	6,176 (100)	3,086 (50.0)	3,090 (50.0)	1,753 (28.4)	1,337 (21.6)
1955	6,043 (100)	2,106 (34.9)	3,937 (65.1)	2,274 (37.6)	1,663 (27.5)
1960	6,057 (100)	2,078 (34.3)	3,979 (65.7)	2,036 (33.6)	1,942 (32.1)
1965	5,665 (100)	1,219 (21.5)	4,446 (78.5)	2,081 (36.7)	2,365 (41.8)
1970	5,342 (100)	831 (15.6)	4,510 (84.4)	1,802 (33.7)	2,709 (50.7)
1972	5,170 (100)	741 (14.4)	4,427 (85.6)	1,404 (27.1)	3,023 (58.5)

Source: The Interim Report of the Census of Agriculture in 1960, 1965 and 1970 (Ministry of Agriculture and Forestry, Japan).

Similarly, as Table 4 demonstrates, there has been a marked decrease in farm household income during the same period, due mainly to increased off-farm earnings.

Table 5 shows the number of people working in agriculture, divided by age and sex. Clearly, the relative importance of both the elderly and females in all age groups has increased sharply. More and more of the young, and especially male, laborers are being employed off the farm, even if they continue to live there. Thus a modern Japanese farm family has both a dual income source and a dual pattern of labor allocation.

Three factors are considered most important in explaining these changing patterns of employment and income. First, the land reform program implemented after World War II, which distributed approximately 2 million has. of agricultural land to the tenants who had been working it, reduced the ratio of tenanted land to total acreage from 46 to 10

Table 4. Annual Farm and Off-Farm Income per Farm-Household in Selected Years

Year	Total Farm-Household Income (1,000 yen <sup>a</sup> )	Farm Income (1,000 yen)	Off-Farm Income (1,000 yen)	Share of Off-Farm Income (percent)
1960	409.5	225.2	184.3	45.0
1965	760.8	365.2	395.6	52.0
1970	1,393.2	508.2	885.2	63.5

<sup>a</sup>US\$1 = ¥360 in 1960, ¥357 in December 1970, IMF parity.

Source: Farm Household Economic Survey (Ministry of Agriculture and Forestry, Japan).

Table 5. Working Population in Agriculture by Age and Sex

Age Group	1960	1965	1970	In 1970	
				Male	Female
16-19	752 (5.4)	406 (3.7)	570 (5.6)	318 (8.0)	252 (4.0)
20-29	2,787 (20.0)	1,398 (12.7)	1,000 (9.8)	345 (8.7)	655 (10.4)
30-39	2,996 (21.5)	2,470 (22.4)	1,795 (17.5)	573 (14.4)	1,222 (19.5)
40-49	2,466 (17.7)	2,194 (19.9)	2,198 (21.4)	746 (18.8)	1,451 (23.1)
50-59	2,424 (17.4)	2,099 (19.0)	1,920 (18.7)	675 (17.0)	1,245 (19.8)
60 and over	2,508 (18.0)	2,471 (22.4)	2,770 (27.0)	1,316 (33.1)	1,454 (23.2)
Total	13,933 (100)	11,039 (100)	10,252 (100)	3,973 (100)	6,279 (100)

Source: The Interim Report of the Census of Agriculture in 1960, 1965 and 1970 (Ministry of Agriculture and Forestry, Japan).

percent and the ratio of tenant farmers to all farmers from 28 to 5 percent. The reform successfully established a system of owner-cultivators, which was supposed to serve as the basis for modernizing agriculture, but also limited the size of holding per household to 3 has., thus preventing the formation of larger, more economically viable farm units. One problem the reform did not address--and which still exists--was the pattern of farmers who owned many very small and scattered parcels. Virtually no consolidation has occurred since the

reform. Hence, it is difficult for a farmer to enlarge his holding except by many purchases of dispersed parcels.

Second, there has been a marked change in the factor market of the agricultural sector: labor has become scarce; hence farm wages have risen steadily. Historically, Japanese agricultural development was achieved by means of land-saving or labor-intensive technology, by using biological innovations, and by increasing the amounts of fertilizer applied to each unit of land. Now, however, they are using more and more machinery. Table 6 indicates the increase in such labor substitution which has occurred since 1945, with a dramatic change taking place around 1960. Surplus labor has been easily absorbed. Much of it has gone, of course, into the increasingly dynamic industrial and service sectors. Some of it has moved into agro-allied enterprises related to the new technology, e.g., the commercial cultivation of rice seedlings which meet the requirements of automatic planting equipment.

Table 6. Major Equipment on Farms  
(1,000)

Year	Power Threshers	Power Tillers	Power Sprayers	Combines
1945	352	8	6	--
1951	972	16	20	--
1955	2,038	89	87	--
1960	2,476	746	232	--
1965	3,048	2,509	494	--
1970	--	3,448	958	45
1972	--	3,529	1,162	117

Source: Farm Machinery Yearbook, 1967, and data from the Statistics and Survey Division, Ministry of Agriculture and Forestry, Japan.

Third, there have been marked changes in patterns of consumption and labor allocation of farm households. The development of mass communications and transportation networks has exposed rural families to urban standards of living, which, as we have seen, they tried to achieve. To do so, higher incomes were needed and these could only be gained by means of off-farm employment as opportunities for higher farm earnings were constrained by the scarcity of, and rigid size-of-holding limitations on, farm land. Hence, part-time farming, rather than full-time, more intensive, or larger-scale cultivation, became the common rural pattern.

With less intensive cultivation, there has come a marked drop in double-cropping. Most farm households now specialize in single-cropping rice, which requires less and less labor due to the development of

suitably small-scale machinery. The typical winter crops of wheat and barley are disappearing: wheat production fell from 3.8 million tons in 1961 to 1 million in 1970.

#### Improvements in Rice Cultivation Techniques

Plowing: Development of Cattle: There are several critical points in the rice farming process as practiced in Japan, especially with respect to labor requirements. The first step in rice farming is plowing paddy fields; second is seeding and transplanting; weeding, insect, and disease control is the third; then harvesting and processing the final produce completes the tasks to be accomplished.

Plowing and preparation of the paddy field by manual labor was very heavy, painful work. (See Figs. 6 and 7.)



Fig. 6: From Thomas Nixon Carver, Elementary Economics (New York, 1920), p. 84, with the legend: "Where power is supplied by human muscles. Rice farming in Japan." Cf. Fig. 7.

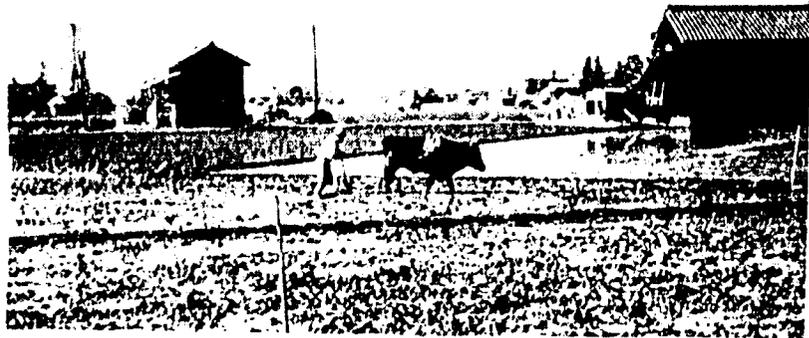


Fig. 7: From Yasusaka Miyazaki (1635-97), Nogyo Zensho (Complete Book of Agriculture) published in 1697 with the sponsorship of Ekken Kaihara. The sketch is idealized, but is in agreement with the findings of historians that draft cattle were used in Japan in those days.

In order to create a larger and more efficient farming scale for higher yields and income from rice farming, farm leaders and government officials introduced the Western plow with Western cattle and horses at the turn of this century. Unfortunately, the effort was not successful in spite of the expenditure of great amounts of money. This failure suggests that improvement of farming techniques cannot occur without the participation of farm people within their own customs and traditional social structures.

Animal scientists, on the other hand, worked with the domestic cattle to breed a powerful draft animal. They crossed such imported foreign breeds as Short Horn, Aberdeen Angus, Hereford, Jevons, Brown Swiss, Ayrshire, and so on, with domestic cattle, and finally found an ideal type of small Japanese cattle as a result of this crossing and selecting. (See Fig. 8.) It is a dual purpose animal: (1) of sufficient power to plow one hectare of paddy field per season (the average

Fig. 8: Japanese cattle used for plowing.



size of a farm in Japan); and (2) able to eat rice straw (which is a by-product of rice farming) along with barley and soybean cakes. It produces fine beef after fattening and service as a draft animal for several years.<sup>5</sup>

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5. Most paddy plowing was carried out using Japanese cattle. Horses were used in some places, including both Tohoku and Kyushu. For rice farming a horse could not compete with Japanese cattle on a feed and depreciation cost basis. Rather, horses were kept in the farm household under policies designed to secure this resource for the army. On the other hand, working horses were found in the upland fields of Hokkaido where farming scale was larger than in the mainland of Japan. However, in the past decade tractors of 40-60 h.p. imported from the United States have been substituted for the work formerly done by the horse.

The number of cattle increased until it peaked in 1960 with almost one animal for every two farm households. With this, the cattle dealers, called "bakuro," became active in rural villages. In cases where a poor farmer could not afford to purchase cattle, some dealers built up a leasing system called "ushi kosaku." The leases were arranged verbally following customary provisions. The dealer brought a young animal to the farm household which the farmer used as a draft animal; in a year or two he exchanged the matured animal for a young one, usually paying but little money. The farmer had the use of the cattle as draft animals; the dealer made a profit by selling the mature, fattened animal. He usually lived in the village and was a man of economic and social power in rural areas. However, his power became weaker and weaker with the development of local cooperative associations to meet the needs for finance and marketing.

Hence, with one or two cattle per farm household to cultivate one hectare of paddy land, the typical pattern of land utilization was established for rice farming in Japan. Unlike the U.S., the cattle were kept in the farmhouse and fed like pets or members of the family.

Plowing: Mechanization: However, working cattle disappeared completely from paddy fields in the early 1960s. The power tiller (see Fig. 9) took over the work. In 1960 the number of such tillers was 746,000; by 1970 it had increased almost five times to 3,448,000.

At the same time, large numbers of cattle were sent from farm households to slaughter houses, having lost their role as draft animals. Since this meant that there was a considerable supply of beef, the price of beef did not increase significantly even though demand due to increased levels of income did rise. In 1968 the number of cattle reached a new low. Then the price of beef increased sharply and "sukiyaki" all but disappeared from the ordinary Japanese diet. The number of cattle have increased since 1968, but this should be regarded as a change in

Fig. 9: A  
small tractor  
used for plowing.



the production pattern emphasizing consumption, though there is still a need for improved marketing of both cattle and beef.

Although the expansion of mechanized plowing in the 1960s was very drastic, there is a long history of Japanese efforts to mechanize rice cultivation.<sup>6</sup>

From the late 1910s to the early 1920s farm people in Japan began to import kerosene engines from the United States. My father was one of them. In partnership with two other farmers he bought a 1-1/2 h.p. "Z" engine made by Fairbanks, Morse Company in Chicago. It was used for rice threshing at first. This system of threshing (see Fig. 10) is still used in some parts of Japan. A "Z" engine was used to work that same system, but the thresher was a simple machine made by the farmer himself. The engine took over from animal-generated power as is shown in Fig. 11.<sup>7</sup>

Soon after, the engine was also used as the power source for irrigation. Originally, irrigation water was carried to the paddy fields using arm-power (Fig. 12), then a wheel system was developed (Fig. 13). Later, the vertical pump driven by a kerosene engine took over the irrigation work in the paddy field.

This engine was used for many purposes, especially threshing, rice polishing, and irrigation. The number of engines increased very rapidly through the drought years in the early 1920s. Witte, International, Alfa, Jumbo, and other brand names were introduced. I remember the development. Most engines introduced were of 3 h.p. capacity.

This engine, fixed, and very heavy, was first used for driving slow moving tractor units, but then, with the addition of a locally invented primitive tiller, was used for rotary type of tilling work. In the beginning the tiller was used to cultivate wheat, a main winter crop on the paddy lands. It was an efficient machine able to smash heavy soil and to control weeds in the wheat which was seeded in lines. Later the

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6. The area most significantly mechanized prior to the 1960s was the southern part of Okayama Prefecture, where tenants had secured their rights to the land by means of group action well before the 1947-48 countrywide land reform.

7. This is a cane sugar crushing machine as used on Shikoku Island. Motive power was generated by blindfolded draft cattle which walked around. The engine was linked to the rotary thresher with a rope belt. The rotary thresher, worked by a man pedaling, was invented later, and the number of these increased.



Fig. 10: Threshing rice with a kerosene engine.  
This is still done on some Japanese farms.

Fig. 11: Cattle generating the power for crushing sugar cane.  
From Gennal Hiraga, Butsurui Hinshitsu,  
vol. 6 (1763). Animal-generated power was also used to thresh rice.

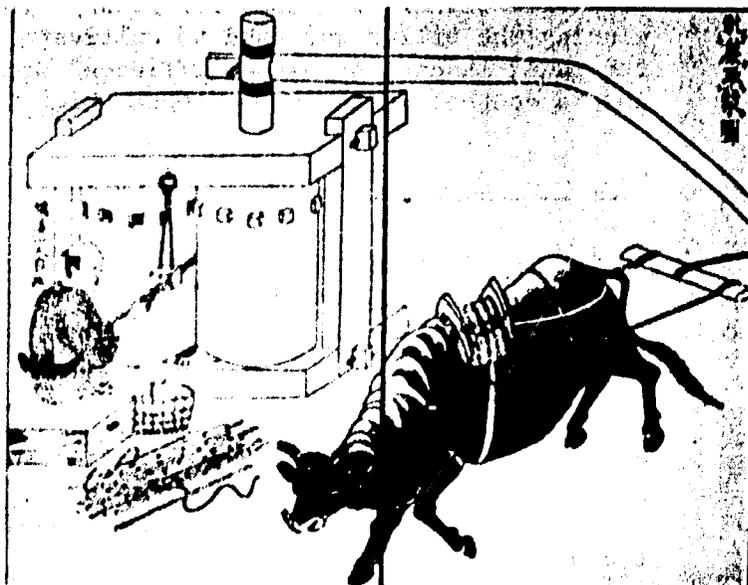
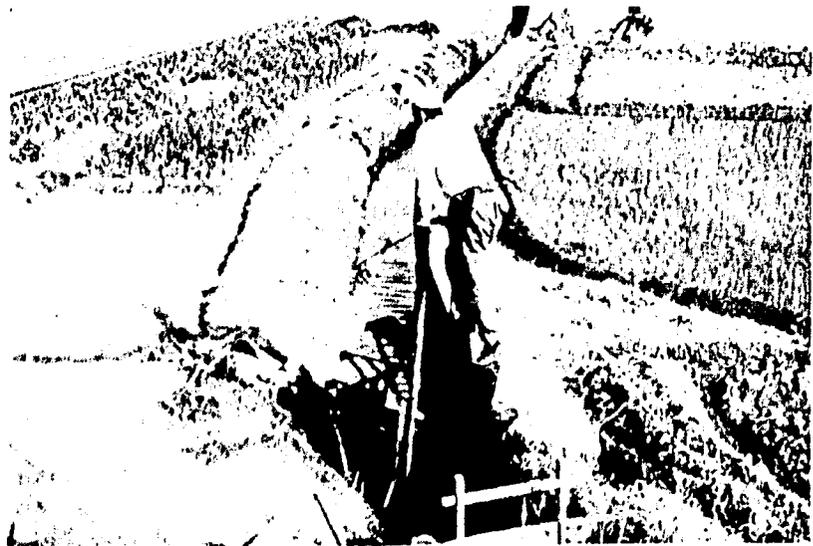




Fig. 12: Irrigation by arm power. From Yasusada Miyazaki, Nogyo Zensho (Complete Book of Agriculture), 1697.

Fig. 13: Irrigation by pedal wheel. The wheel has wings which push water up. It is turned by the man's weight on the wings which are out of the water. I have experienced this irrigation system.



tiller was used in place of traditional deep plowing for rice.<sup>8</sup> The rotary tilling system for rice expanded in the southern part of Okayama Prefecture, the northern part of Kyushu, especially Fukuoka Prefecture, and Niigata Prefecture. These are heavy soil areas. Farmers there needed to decrease the competitive relationship between labor for harvesting wheat and transplanting rice by using the efficient tilling system, and they enjoyed a stable land tenure system with secure rights for the cultivator.

This type of tiller was used for several years after World War II. At that time nobody believed that the tiller could be used in irrigated paddy fields. But a great change took place with an improvement of the tiller which was equipped with its own engine as well as the exchangeable wheels for use in both upland and irrigated paddy fields. (See Fig. 14.) The dramatic increase in the number of tillers since 1960, as mentioned above, might be partially explained by these improvements. (See also the earlier discussion of increased mechanization on page 12 and in Table 6 supra.)

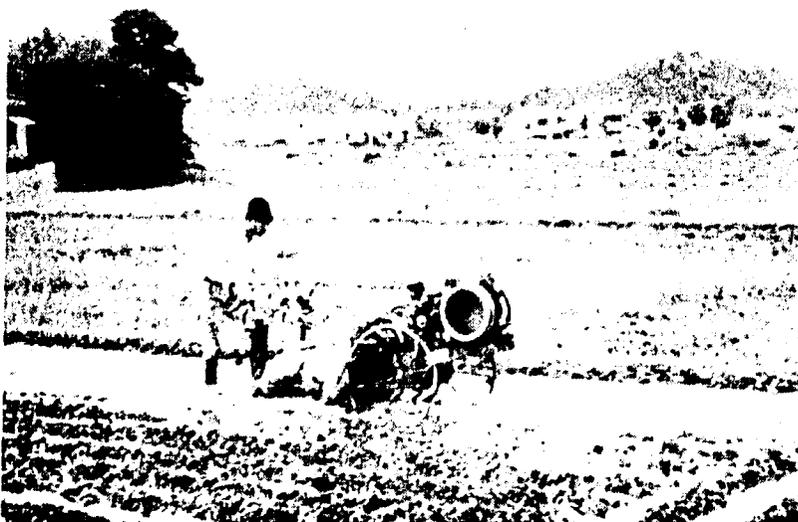


Fig. 14: A primitive rotary tiller.

In the meantime, the Ministry of Agriculture, as a part of the Improvement Agency for Agricultural Structure, encouraged the introduction into rice farming of imported tractors of 40-60 h.p. The Government also subsidized the purchase of tractors by agricultural cooperatives.

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8. During the 1930s there were many controversies over mechanization of plowing in Japanese agriculture, especially in regard to the expanded use of the multi-purpose, fixed kerosene engine equipped with the rotary tiller.

In recent years, the use of riding types of small tractors equipped with 14-30 h.p. engines, of a type familiar to Americans, has been increasing. (See Figs. 15 and 9.)

Developments in Rice Transplantation: Following completion of plowing and soil preparation, the rice seedlings are transplanted. Direct sowing in the irrigated paddy field, or in dried-out paddy field is found in Japan, but this is not the prevailing method.<sup>9</sup> Fig. 16 shows the method of transplanting which can be seen in most parts of Japan at present; it is not very different from the seventeenth-century method shown in Fig. 17. In the traditional transplanting method seedlings are grown in a nursery. Pulling up the rice plant from the nursery soil (Fig. 18) is not easy work, and is usually done by women. In colder areas the nursery soil is covered with plastic film to keep in the warmth. In some cases, an electric heater is applied to the field nursery. With this development, together with new varieties highly resistant to cold weather which came with the development of rice borer chemical control, rice farming in Japan has been expanded to the northernmost areas and to higher elevations, using earlier transplantings and harvest.

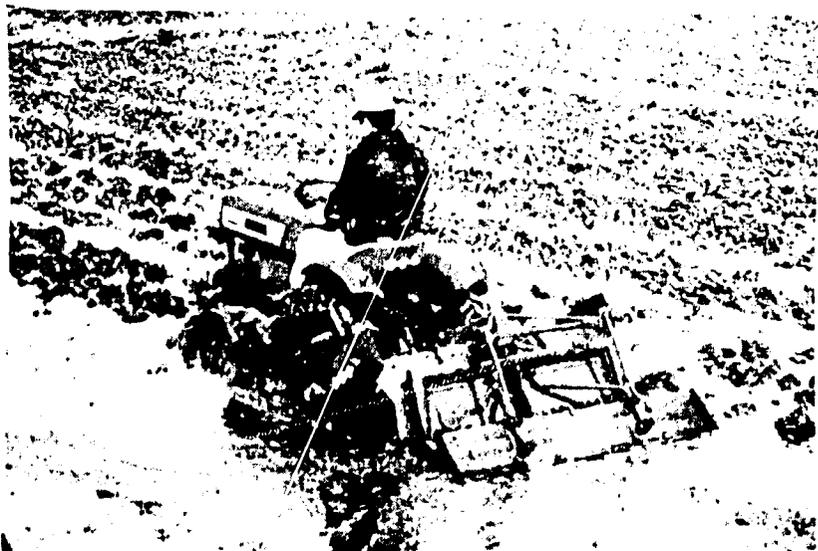


Fig. 15: A more advanced tiller in an irrigated paddy field.

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9. Methods of transplanting rice in Japan had to be developed within the constraints of: a) vegetative weeds; b) vigorous insects, especially rice-borer; c) climate where the period of stable summer weather is rather short for growing rice; d) cropping system designed for intensive utilization of the cultivated land. A number of seedling varieties were developed by breeding through crossing, selecting, and fixing, to allow transplanting despite these difficulties.

In recent years, a) and b) are no longer limiting factors because of the development of chemical control, but c) is still a general



Fig. 16: Still the prevailing method of rice transplantation in Japan--covering 68 percent of the paddy field in 1973.

Fig. 17: A method of transplanting rice. From Yasusada Miyazaki, Nogyo Zensho (Complete Book of Agriculture), 1697.



Fig. 18: Hand-picking rice seedlings from nursery soil.

Now a rice planting machine has been invented which has resulted in a great change in Japanese rice farming because it is not just a mere substitution of machine power for manual work but it involves a whole new way of organizing the rice farming system in an area.<sup>10</sup> Instead of seedbeds in the field, the machine needs a set of rice seedlings raised in a box. Thus, under the new system seedlings are prepared indoors. First, bags of rice seeds are soaked in water. While this is being done, the boxes to receive the seed are carefully prepared (see Figs. 19 and 20).<sup>11</sup> Seedling-filled boxes are placed on shelves in wheeled racks. They are kept in rooms automatically controlled for heat and humidity: first in a germinating room, then in a lighter, "greening room," and finally in a greenhouse (Fig. 21) covered with plastic film where they remain until ready for transplanting (this step is not

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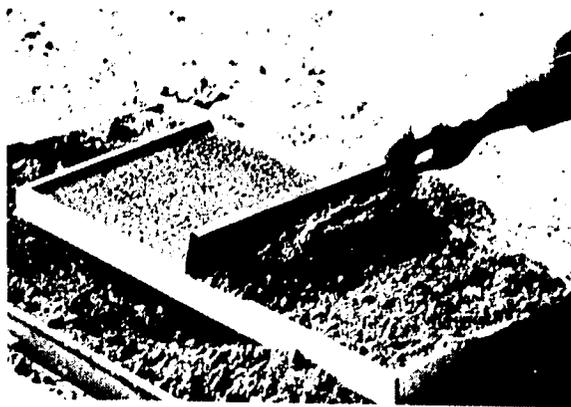
restraint. Furthermore, most varieties good for transplanting are apt to fall before harvest if they are seeded directly in the irrigated paddy. This makes for other difficulties in harvesting and a larger grain loss at the harvest. This problem does not arise in direct seeding into dried paddy which is not converted to irrigated paddy until the young rice plant grows to 10-15 centimeters. But this method is not possible in wet paddy and is often disturbed by rainfall in the critical seeding period anyway.

10. When we began a study on rice farming with mechanized field work, using analysis of the farm-books kept by farmers and an interview survey for the development and institutional problems, it was evident that operation of the rice transplanting machine had many problems. Furthermore, most farmers were skeptical of its work capabilities, particularly as to whether the system would secure the production per area of paddy field, even if it decreased painful labor inputs.

The early adopters among farmers found that machine transplanting did not decrease the production per area of land but rather increased it. Our studies have made this generally clear from the farm records kept by farmers.

The machine was improved in a few years and then the number increased very rapidly. By 1973, 32 percent of the paddy field area in Japan was planted in this way.

11. This box seedling method is applicable to small-scale rice farming households. It could easily be assembled on a conveyer with a set of machines for the preparation of soil, seeding, irrigation, etc.



Figs. 19 and 20: Hand preparation of rice seedling boxes for machine transplanting.

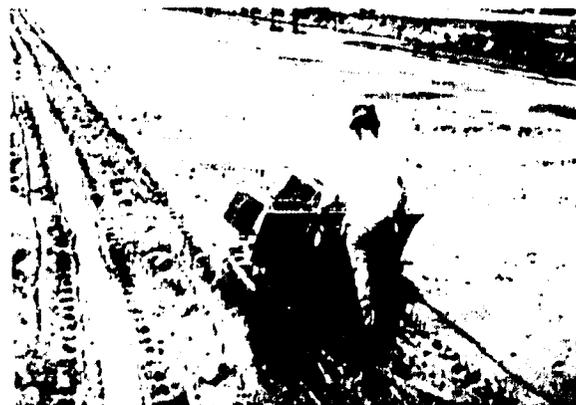
Fig. 21: Plastic-covered greenhouse for rice seedling boxes.





Fig. 22: Boxed rice seedlings ready for transplantation.

Figs. 23 and 24: Machine transplantation of boxed rice seedlings.



necessary in warmer areas.<sup>12</sup> Seedlings ready for transplanting (Fig. 22) are carried to the paddies by truck in their boxes and placed directly onto the planting machine (Figs. 23 and 24).

The new method of rice transplanting needs 10-20 hours of male work per hectare of paddy field, while the traditional method involved 150-300 hours. This means that the new method requires only 1/15 of the labor input used in the traditional method. If a farm-household cultivates one hectare of paddy rice with this transplanting machine, it only takes 1-2 days. Using the machine, it is possible to serve 10-20 hectares of paddy field if the operating dates are spread over 20 days and the paddy fields are integrated in one place. We should note, however, that the method can only be used in paddies where the irrigation is well controlled and there are no flooding problems.

One of these seedling plants has the capacity to supply the seedlings for 200-300 hectares of paddy field over a 20-24 day period. For each hectare 170-180 boxes of seedlings are required. The cost per seedling box supplied by one cooperative plant I investigated was lower than an equivalent amount of seedlings prepared by manual labor. Unit cost per box could be further lowered if more boxes are produced on a regular basis. For this to happen a system of transplanting across individual farm boundaries would be necessary. Costs could be further reduced by standardizing varieties of seedlings supplied (and hence transplanting dates) and by development of a coordinated harvesting machine.

The supply of the transplanting machine has been effecting significant changes in rice transplanting. At present it is possible to find several ownership and use patterns, as follows: 1) individual use of one's own transplanting machine; 2) a machine owned by a minor cooperative, operated by members who specialize in the use of the machine; 3) custom work by an individual farmer who owns a machine, but who has a small-scale farming operation and a larger available labor force than needed; 4) custom work by the cooperative association for nonmembers, with machines operated by members or agents of the cooperative under leasing contracts.

The rice transplanting machine was only invented by the farm equipment manufacturing companies very recently. The rice seedling boxes used were also developed by the manufacturers. The introduction of more transplanting machines might have even greater potentials for rural development. This, however, depends on the modification of the Agricultural Land Law and the organized actions of the owner-operator farmers. A rice farming unit could be enlarged by an organized or integrated farm, either with increases in nonfarm work or with intensification of some enterprises, such as orchard, greenhouse, poultry, etc.

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12. These seedling operations are usually built and operated by a minor cooperative, which consists of several farmers.

Change in Harvesting: Fig. 25 illustrates the seventeenth-century system of harvesting. Beginning in the 1960s large combines were introduced with the help of government subsidies, but despite the shift to a labor-scarce economy they were not very successful. Until very recently the most prevalent harvesting machine was a binder. This does not represent much of an advance over the ancient system; it merely substitutes mechanization for a part of the painful hand work.

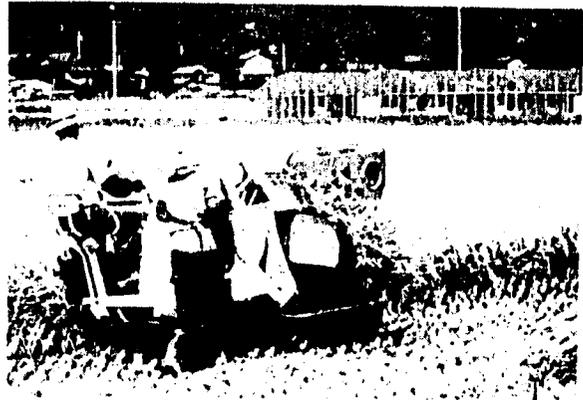
Several years ago, however, a small combine was invented. As Figs. 26 and 27 show, it is a light weight and a workable machine, even in

Fig. 25: Cutting and making bundles of rice. From Yasusada Miyazaki, Nogyo Zensho (Complete Book of Agriculture), 1697.



soft paddy fields. Since the beginning of the 1960s, with the help of government subsidies, more of these machines have been introduced as a way of increasing production. It is really a combination of the same thresher that has worked for years and a modified rice binder. The first model was equipped with only a 7 h.p. engine and the operator walked behind the machine, like the operator of the Japanese tiller. A riding type was devised later on and the power has increased.

The combine harvest has brought a dramatic change. The traditional rice harvest procedure in Japan included the following steps: 1) cutting down the rice stems, a few inches above the soil (Figs. 28 and 29); 2) making bundles, usually with old rice straws; 3) hanging the bundles on wooden or bamboo bars bound to the growing trees by the paddy or temporarily erected poles (Fig. 30), or simply piling it in windy places for weeks; 4) threshing when moisture in the rice grain



Figs. 26 and 27: Small rice combines.

Fig. 28: Cutting rice stems.





Fig. 29: Cutting rice stems and making bundles.



Fig. 30: Hanging rice bundles to dry.

Fig. 31: Hand-threshing rice in the seventeenth century. From Yasusada Miyazaki, Nogyo Zensho (Complete Book of Agriculture), 1697.



was about 18 percent (Fig. 31); 5) drying paddy rice to the 13-14 percent moisture required for storage.

The new Japanese type of combine requires standing rice plants for efficient work. As a result, rice grain is harvested at higher moisture levels, i.e., when rice stems are still green.

The combine harvester cuts out several steps which had been required for the traditional system. It enables the field work to be carried out with 20 hours per hectare. However, it does not work smoothly without proper drying and storage systems. Hence new processing plants, called "dry stores" are being built and operated by local cooperative associations. These small plants can handle possibly 200-300 hectares of paddy produce, which means that on the average the service can cover 200-300 farm households.

The new rice harvest system makes useless the traditional equipment in every farm household. Furthermore, it substitutes income from family labor inputs for an operational expenditure in a farm economy. Local cooperative leaders in rice-growing areas, however, regard it as an improved process of collective marketing, even if some farm households are partially subsistence rice producers. The interesting facts are to be found in the organized activity of farm people who are in small-scale, owner-operated farm households.

### Summary

Farming in Japan, an over-populated, traditional country, experienced two phases of development:

First: Intensive land use with improvement of dual purpose cattle, under a labor-surplus economy. In this period the land reform, which made a change from unstable tenant farming to an owner-operated farming system, stimulated the input of more labor on, and production of higher yields from, the paddy fields. Mechanization started in this phase and it developed with more labor inputs and with higher farm income. It was, of course, based on a stable land tenure system.

Second: With the change to a labor-scarce economy, farming has been significantly mechanized. But this mechanization has not been accompanied by enlargement of the scale of farming but by increasing off-farm work. The development, however, as we have seen, decreased the intensity of land use with the abandonment of winter crop production. In other words, Japanese agriculture has been specializing more and more on rice production.