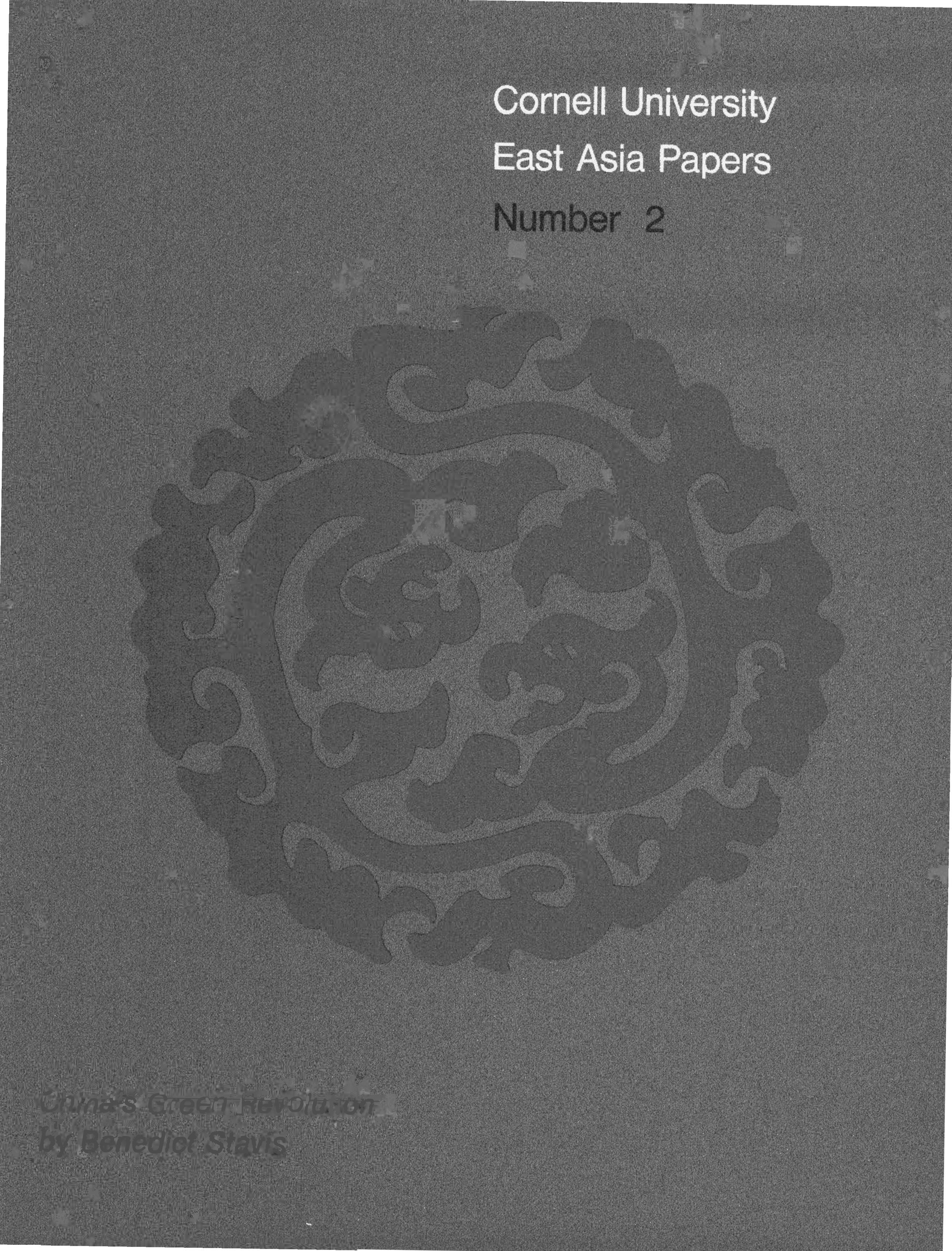
Cornell University
East Asia Papers
Number 2



China's Green Revolution

by Benedict Stavis

CHINA'S GREEN REVOLUTION

Benedict Stavis

China-Japan Program

Cornell University

Ithaca, New York 14850

January 1974

The Cornell East Asia Series is published by the Cornell University East Asia Program (distinct from Cornell University Press). We publish affordably priced books on a variety of scholarly topics relating to East Asia as a service to the academic community and the general public. Standing orders, which provide for automatic notification and invoicing of each title in the series upon publication, are accepted.

If after review by internal and external readers a manuscript is accepted for publication, it is published on the basis of camera-ready copy provided by the volume author. Each author is thus responsible for any necessary copy-editing and for manuscript formatting. Address submission inquiries to CEAS Editorial Board, East Asia Program, Cornell University, Ithaca, New York 14853-7601.

Number 2 in the Cornell East Asia Series

ISSN 1050-2955 (formerly 8756-5293)

ISBN-13 978-0-939657-02-5 / ISBN-10 0-939657-02-3

Table of Contents

Regions of Modern Agriculture in China
(Late 1960's)

China's primary agricultural land
(30% or more of the land in these regions is in cultivation.)

Regions where agriculture is basically modernized (late 1960's)

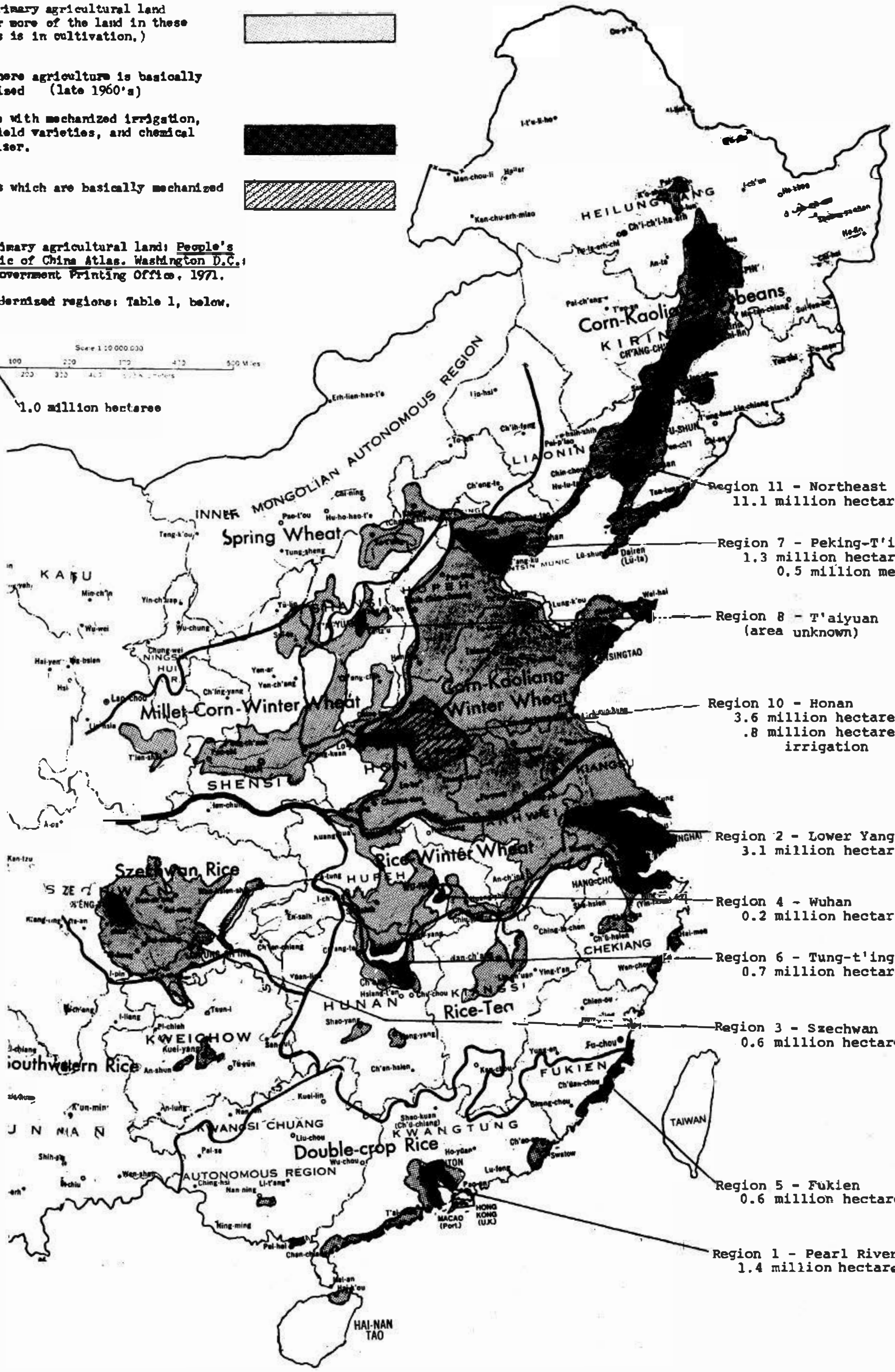
Regions with mechanized irrigation, high yield varieties, and chemical fertilizer.

Regions which are basically mechanized

Source:
For primary agricultural land: People's Republic of China Atlas. Washington D.C.: U.S. Government Printing Office, 1971.

For modernized regions: Table 1, below.

1.0 million hectares



Region 11 - Northeast
11.1 million hectares mechanized

Region 7 - Peking-T'ientsin area
1.3 million hectares total
0.5 million mechanized

Region 8 - T'aiyuan
(area unknown)

Region 10 - Honan
3.6 million hectares mechanized
.8 million hectares with mechanized irrigation

Region 2 - Lower Yangtze Valley area
3.1 million hectares

Region 4 - Wuhan
0.2 million hectares

Region 6 - Tung-t'ing Lake area
0.7 million hectares

Region 3 - Szechwan
0.6 million hectares

Region 5 - Fukien
0.6 million hectares

Region 1 - Pearl River Delta
1.4 million hectares

INTRODUCTION*

During the 1960's China's agriculture underwent extensive technological changes, so that by the end of that decade roughly 20 percent of her cultivated area (i.e., about 25 million hectares) had modern agriculture. Of this, about 10 million hectares have both mechanical irrigation and new seed technologies (and probably chemical fertilizer); probably another 15 million hectares are basically mechanized. Table 1 and the map above give rough estimates concerning the location and size of the various areas in China with a modern agriculture.

In these areas, which the Chinese call "high and stable yield areas," food production is basically assured by mechanized irrigation. Neither flood nor drought will influence production very much. Large supplies of chemical fertilizer and careful seed selection result in high yields. Moreover, because water supply can be regulated very carefully, because more crop nutrients are available, and because more mechanization is available to deal with peak season labor shortages (e.g., when harvesting the first crop and planting the second crop), cultivation can be greatly

---

*This paper is part of a more extensive study to be published by the Rural Development Committee of the Cornell Center for International Studies, Making Green Revolution: The Politics of Agricultural Development in China (1974). That monograph traces the political, economic and social policies used to achieve the changes described in this paper.

Many people have given me important assistance in preparing this study. Richard Sorich gave crucial bibliographic suggestions. Interviewing in Hong Kong (which confirmed the general conclusions) was supported financially by the National Science Foundation and logistically by the University Service Centre. The China-Japan Program and the Center for International Studies at Cornell have given me important encouragement and support to complete this work. Many friends and colleagues have read and criticized earlier drafts of this study, especially Michel Oksenberg, John Mellor, Kenneth Robinson, David Mozingo, and Norman Uphoff.

Table 1

Areas of Modern Agriculture in China, Late 1960's
(million hectares)

Area	Total Modern Agriculture (Sown Area)	Mechanical Irrigation	Very High Yielding Seeds	Area Plowed By Tractors
Rice Areas				
1 Kwangtung-Pearl River Delta	1.4	0.4	1.5	
2 Shanghai-Nanking area	3.1	3.1	0.71	
3 Szechwan	0.6	0.6	tested	
4 Wuhan	0.2	0.13	tested	
5 Fukien	0.6	0.6		
6 Hunan, Changsha, Tung-t'ing Lake	0.7	*	tested	
Rice Area Subtotal	6.6			
Wheat and Other Crop Areas				
7 Peking-Tientsin area	1.3	1.3	0.08 in Peking	0.5 in Peking
8 Shansi-Taiyuan	*	*		
9 Changchun, Kirin	0.2	*	reported	
10 Honan, Cheng-chow, Loyang	3.6	0.8#	tested	3.6
11 Northeast	11.1		reported	11.1
Total identified in these areas	22.8	6.9	2.3	15.8
Total estimated in 1971		9.0	7.7 (mid 60's)	21.0

*It is known that modern agriculture exists in this location but the extent is not known.

#Estimated, other figures reported.

intensified. For example, in the Hangchow area of Chekiang province, communes plant two rice crops and one wheat crop annually instead of only one crop.[1]

The rest of China's cultivated area is in a transitional phase. These areas have some modern inputs, but not the full set of complements required by modern agriculture. They also have improved seeds (although not extremely high yielding), improved cultivation techniques, or may have some chemical fertilizer, mechanization and electrification.

From 1956 to 1971 Chinese grain production grew from roughly 190 million tons, a plateau for grain production under traditional technology, to almost 250 million tons. Of this increase of 60 million tons, the modern sector (with one-fifth of the cultivated area) accounted for about 42 percent.

From the point of view of overall percentage increases in production, the annual growth of production from 1956 to 1971 (both good years) has been about 1.9 percent, roughly equal to population growth. However, in high and stable yield areas, the growth rate in grain production has been well above 1.9 percent. Of course, in other areas the growth rate has been somewhat less, roughly 1 percent. Thus it would appear that China has not found a way of making backward areas develop their agricultural productivity at a high rate, in the absence of modern inputs.

---

[1] Annette Rubinstein, "How China Got Rid of Opium," Monthly Review, October 1973, p. 60. Similar examples are numerous. In Wushih County, Kiangsu, an extra rice crop has been added to the traditional one rice crop and one wheat crop. ("A Double Approach to More Fertilizer," China Reconstructs, August 1973, p. 25.) In the Tungt'ing Lake area of Hunan, intensified cultivation at one commune increased average grain yields from 3.0 to 9.75 tons per hectare. ("Silted Land Transformed," China Reconstructs, October 1973, p. 10.)

Table 2

Estimates for Area, Yield, and Production of Food Grains

1957, 1971

	1957[1]				1971[2]			
	Sown Area (million hectares)	Yield (Tons/ hec- tare)	Produc- tion (million tons)		Sown Area[3] (million hectares)	Yield (Tons/ hec- tare)	Produc- tion (million tons)	
Rice	32.2	2.69	87	regular	27.6	3.0	83	111
				high-stable	6.6	4.2	28	
Wheat	27.5	.86	24	regular	7.5	1.1	8.3	42
				mechanized	17	1.5	25.5	
				high-stable (and mechanized)	3.0	2.9	8.0	
Coarse Grains	50.6	1.04	53		58.6	1.2		70
Potatoes	10.5	2.09	22		10.5	2.3		24
TOTAL			186					247

Sources and notes

1. Figures for 1957 are official Chinese figures given in Ten Great Years.
2. Estimates for 1971 are based on figures contained throughout this paper.
3. We assume an expansion of sown area of 10 million HA. It is assumed that of this, expansion of rice planting (through expansion of areas of multiple cropping) account for 2 million HA. The remaining 8 million HA are presumed to be planted to coarse grains.

Table 3

Estimates for Source of Growth in Grain Production

Type of Region	Sown Area (million hectares)	Increase in Yield/Ha. (metric tons)	Increase in Total Grain Production (million tons)	
			modern sector	regular sector
Rice				
High yield land	4.6	1.20	5.5	
New rice land	2.0	4.20	8.4	
Regular sector	32.2	.31		10.0
Wheat				
High yield land	3.0	1.80	5.4	
Mechanization	17.0	.40	6.8	
Regular sector	27.5	.24		6.6
Other crops				
Expanded area	8.0	1.20		9.6
Regular improvements	61.1	.16		9.8
			26.1	36.0

This conclusion is somewhat striking, because the Chinese often attribute their success to unique forms of social organization and mass mobilization. I certainly would not argue that social organization and political mass mobilization are irrelevant. Indeed, they have been very important in changing class relations in China and in developing patterns of distribution of food and other values that stress equality and security. From the point of view of production, organization and mobilization have also played a role, providing the labor inputs needed to level and terrace land and to build water conservancy projects. Social organization and mass mobilization have, then, been complements to modern inputs. They have not, however, been able to substitute for the modern inputs, which remain absolutely essential for

continued growth of China's agriculture. Chinese leaders recognize this, and in late 1973 contracted to buy chemical fertilizer factories which will come close to doubling their already huge capacity.

Continued expansion of agriculture in the 1970's may be a greater challenge than it was in the 1960's. Much of the improvement in the 1960's was in areas which were already well developed and had good water supplies (e.g., the Pearl River Delta, Lower Yangtze valley, and the central lake areas). The scientific breakthroughs needed to increase rice production for such regions were relatively simple (and have been duplicated in most Asian countries). For the 1970's there will be harder problems, which have not yet been solved adequately in other countries: controlling pests and diseases in high and stable yield areas; improving yields in the temperate latitudes, where the growing season is too short for multiple cropping, and where water resources are not good.

An indication of the problems China faces is suggested by the fact that food grain production grew very rapidly (at 6.0 percent annually) from 1964 to 1967, as the first generation of modern techniques were popularized. Since 1968, however, food grain production has grown at less than 1.0 percent. We can expect to see increased mobilization of China's scientific and technological resources, as well as increased contact with agricultural scientists throughout the world, as China tackles the complex agro-technical problems of the 1970's.

One of the ways China has been testing as a way of dealing with these problems has been new patterns of inter-cropping and multiple cropping. In Tangshan Special District, Hopeh province,

an area about 100 miles east of Peking that does not receive special emphasis in industrial supplies, methods of double harvesting can produce a grain yield of 6 tons per hectare and triple harvesting can bring 7.5 tons per hectare. Experiments were being carried out with quadruple planting and planting seven times in two years.[2] This pattern of agricultural development is distinctive in that it prevents mechanization of harvesting, complicates mechanization of plowing and increases labor requirements. It naturally requires many complementary inputs--especially fertilizer and water, as well as machinery, to process the harvest and release labor for intensified cultivation. The Chinese feel that this pattern of development is appropriate for areas that lack industrial supplies but have much labor power. It is not yet clear whether this pattern will emerge as an important way of raising productivity in the 1970's.

Compared with other countries in Asia, China's experiences in transforming agriculture can be considered successful. Food production has risen slightly more rapidly than in the rest of East, Southeast and South Asia. On an overall average basis, China's agriculture is the most advanced in Asia, after that of Japan and Taiwan; and China's high and stable yield areas are comparable to the best areas in Japan and Taiwan. In terms of future prospects, China's difficulties are certainly no greater than those of other countries.

This paper examines the green revolution in China from four points of view. The first section reviews trends in grain production

---

[2]Discussion with Tangshan Special District, Agricultural Department, April 21, 1972.

in China which suggest rapid growth in the 1960's. The second section analyzes in detail the character and extent of technological changes in China's agriculture, especially those taking place in the 1960's which made possible the growth in food production. The third section investigates the relationship of food production to other agricultural activities. The fourth section compares China's agro-technical development with that of other Asian countries.

I. Grain Production in China

The question of food production in China is subject to intense debate among analysts of China because there are serious problems regarding the availability, accuracy, and comparability of data. China released much data for the period before 1958 on a province-by-province basis, which Kang Chao has used to estimate total grain production.[3] His estimates for total production are higher than the official total figures offered by the Chinese government, but also imply a lower growth rate. Chao believes the discrepancy is due to incomplete compilation of sown land statistics before 1957. Chao's analysis seems convincing, and I have used his figures for the period before 1958.

For the period after 1958, I prefer to rely exclusively on the Chinese claims. For the period 1960 to 1965, the Chinese figures are widely accepted by Western observers. For the period after 1965, however, there is great debate on the accuracy and comparability of statistics offered by China. Some observers

---

[3] Kang Chao, Agricultural Production in Communist China, 1949-1965 (Madison: University of Wisconsin Press, 1970).

Table 4

Grain Production in China

Year and Period	Grain-equivalent production, million metric tons	Index 1961-65=100	Increase %	Average for period
Recovery from War				
1949	134			
1950	143		6.7	7.3
1951	155		8.4	
1952	166		7.0	
First Five Year Plan				
1953	170		1.5	
1954	176		3.5	
1955	182		3.4	2.1
1956	188		3.3	
1957	186		-1.1	
Great Leap, Crisis, and Recovery				
1958	205		10.2	
1959	170		-17.1	
1960	150		-11.8	0.3
1961	160	88	6.7	
1962	170	94	6.2	
1963	182	100	7.1	
Period of Rapid Technological Change				
1964	195	108	7.1	
1965	200	110	2.6	6.0
1966	220	121	10.0	
1967	230	126	4.5	
Period of Stagnation				
1968	(234)	128	1.7	
1969	(237)	130	1.3	
1970	240	132	1.3	0.9
1971	246	135	2.5	
1972	240	132	-2.4	

Sources for Table 4

1949-65: Kang Chao, Agricultural Production in Communist China, 1949-1965 (Madison: University of Wisconsin Press, 1970), pp. 227, 246.

1966: Han Suyin, China in the Year 2001 (New York: Basic Books, 1967), p. 54.

1967: Anna Louise Strong, "Letter from China," January 1, 1968.

These estimates for 1966 and 1967 are fairly consistent with estimates the Chinese made before the end of 1967. In October 1967, Hsieh Fu-chih estimated that the 1967 grain harvest would be 9 to 10.5 million tons higher than the previous year. "Vice Premier Hsieh on 'Fight Self, Repudiate Revisionism,'--Excerpts of his speech at the Standing Committee meeting of Peking Revolutionary Committee in the Afternoon of October 5," Canton Wen-ke T'ung-hsun (Cultural Revolution Bulletin) November 8, 1967. SCMP 4076 p. 1. Later in the year, Chou En-lai predicted that grain output would rise 5-6% in 1967. "Premier Chou's Speech to Canton Delegations to Peking on the Morning of November 14," Canton, Tzu-liao Chuan-chi (Special Reference Material Supplement), November 17, 1967. SCMP 4080 p. 4.

1968-69: These are arbitrary figures that produce smooth rates of growth to 1970.

1970: Edgar Snow, "Talks with Chou En-lai: The Open Door," New Republic, Vol. 164, No. 13 (March 27, 1971), p. 20.

1971: First reports were 246 million tons. "New Leap in China's National Economy," Peking Review, No. 2 (January 14, 1972), p. 7. A revised figure of 250 million tons was reported in "China Reaps Good Harvest in 1972," Peking Review, No. 1 (January 5, 1973), p. 13. The change is probably due to rounding, because later a Chinese economist again used the figure 246 million tons. Chung Li-cheng, "China's General Principle of Developing the National Economy," Peking Review, No. 33 (August 17, 1973), p. 6.

1972: First estimates put the total grain output at 240 million tons. "China Reaps Good Harvest in 1972," Peking Review, No. 1 (January 5, 1973), p. 12. Before the end of the year, Chou En-lai told a visiting Scandinavian group that agricultural production for 1972 was about four percent lower than for 1971. "Economic Growth Declines in China," New York Times (December 5, 1972)

believe the 1970 to 1972 figures are too high. Others report that the recent figures are really too low because they do not include production on private plots, harvesting losses, and potatoes.[4]

My own view is to assume that the figures are comparable, on the weak basis that Chinese economists use these figures for comparison with earlier years. The size of potential error caused by exclusion of private plots is small, as very little grain is grown privately; harvesting losses are probably small. If potatoes are not included in current statistics in the manner they were in the 1950's (namely by counting 4 units of potatoes as 1 unit of grain equivalent), then the potential error is significant, for potatoes constituted roughly 12 percent of the grain equivalent in 1957.

An important reason for adopting Chinese figures is political, in a broad sense. As relations between the United States and China improve and as the possibilities for scholarly exchanges grow, it is appropriate to accept China on its own terms and to use data they release whenever credulity is not strained. In this case, the Chinese figures seem reasonable; the average compound growth rate of food production from 1956 to 1971 (both were years with good harvests) was 1.9 percent. This is virtually identical with population growth, so that per capita availability of food is almost the same in 1971 as in 1956. That food production has kept up with population growth is not difficult to believe, and represents success compared with the situation in some countries; but it does not imply spectacular success. Admirers

---

[4]Curtis Ullerich, "China's GNP Revisited; Critical Comments on a Previous Estimate," Journal of Contemporary Asia 3(1) (1973)t, p. 48.

of China can not say that my analysis underestimates China's success since my conclusions rest on Peking's own statistics.

It is well to point out exactly to what the figures refere Chinese grain production figures refer, in reality, to "grain equivalent" of several crops. Rice, wheat, and coarse grains are included at 100 percent of their production. Potatoes are included at 25 percent of actual productione (This makes sense, as potatoes have only about 25 percent of the caloric value per unit of weight as do the cereals.) Soya beans and other pulses are not included in the Chinese figures. The relative importance of different food crops is shown in Table 2.

It should also be pointed out that the Chinese figures refer to the total production of grain, before it is processed. To compute the amount available for human consumption, processing losses must be computed (about 30 percent for rice, about 15 percent for wheat and coarse grains), and subtractions must be made for other uses of grain, the most important being seed for the following year's crop. Some may be used for animal feed or for brewinge There is also a certain amount lost or damaged in transportation and storagee In addition, figures before 1960 are on the basis of biological yields, so harvesting losses must be subtractede It is possible, but not certain, that some of the figures for the 1960's refer to grain that has been harvested, and for which no correction need be made for harvesting lossese

Close examination of the production statistics suggests that there are two broad periods of agricultural developmente Before 1957 there was a period of growth through the mobilization of traditional inputs. This brought grain production to about 185 to

190 million metric tons, but production could not rise above that plateau. After 1963, a technological transformation of agriculture began, which permitted grain production to rise above what had been possible previously.

Actually, a more complete analysis breaks both the period of traditional transformation and technical transformation into two periods, and would add an additional transitional period when China experimented briefly with a "super-mobilization" policy. These five periods can be described as follows:

A. Mobilization of Traditional Resources

1. For the first years after the victory of the revolution, agricultural production grew very rapidly at an average of 7.3 percent. This reflected the termination of disruptions associated with over a decade of international and civil war.

2. From about 1952 to 1957, during China's first Five Year Plan, agricultural production increased slowly, at an average rate of growth of 2.1 percent, about the same rate as population increase. In general, this growth in agriculture was caused by increased utilization of traditional resources, especially labor. One important aspect of agricultural development during this period was the repairing of irrigation systems so that the pre-war system could be brought back into full use.[5] By 1957, the

---

[5]The data on irrigated area is not precise, but good enough for this sort of broad generalization. During the 1930ès, the irrigated area in China was somewhere between 26 million hectares and 39 million hectares. The range of possible amounts of area is due to the fact that irrigated area is estimated by multiplying cultivated area by percent of land irrigated. For both values there is uncertainty. Estimates for cultivated area range from 94 million hectares (Dwight Perkins, Agricultural Development in China, 1368-1968, Chicago: Aldine, 1970, p. 236) to 111 million hectares (Kang Chao, Agricultural Production in Communist China,

traditional resources were fully utilized, and agriculture could not grow without a structural transformation in which agricultural inputs began to come from the industrial sector.[6]

B. Transition

3. From 1958 to 1963, China's agricultural production first went up sharply, then dropped into a deep depression and recovered. The sharp decline had many causes, bad weather being one of them. But the crisis was also caused by the policy of the Great Leap Forward, which held that agricultural production could increase through intensification of cultivation. Labor inputs were considered the main restraint on production, so rural society was reorganized into communes in an attempt to increase the labor supplies for agricultural production. This policy did not work because China's agriculture was already at a plateau, fully utilizing the resources available. Modern inputs, including chemical fertilizer and energy, were needed to rise beyond this plateau. Unfortunately, because China's agriculture used traditional resources so efficiently, it was delicately balanced, and was seriously disrupted as a result of the unsuitable policies. A sharp

1949-1965, Madison: University of Wisconsin Press, 1970, pp. 193-207). Estimates of irrigated percentage range from 31% to 42%. (John Lossing Buck, Land Utilization in China, New York: Paragon, 1968, pp. 188, 232, supplies figures which must be weighted to achieve proper geographic balance.) A detailed discussion of this can be found in Benedict Stavis, "Political Dimensions of the Technical Transformation of Agriculture in China," Columbia University Ph. D. dissertation, 1973. Appendix 1.

For the 1950's, the statistics on irrigated area are not precise either. For 1953, however, they range from 24.0 to 31.0 million hectares. By 1956, the irrigated area was somewhere between 32.0 and 37.6 million hectares. Owen Dawson, in Buck, Dawson and Wu, Food and Agriculture in Communist China, New York: Praeger, 1966, p. 156, conveniently sums up Chinese statistics published in a variety of sources.

[6]Dwight Perkins, op. cit., p. 16.

drop in food production followed the attempted Great Leap. By 1963, China had recovered from those disruptions and was back on the plateau of food production at about 185 million tons.

C. Technical Transformation

4. From 1964 to 1967, China's grain production rose very rapidly, at an average of 6.0 percent each year.[7] This is the period that China had its green revolution. Because China had already reached its ecological limits for food production in the 1950's, the rapid growth during the mid-1960's is especially important. It reflects structural change in China's agriculture and indicates that China entered a new historical epoch in which agriculture is based on scientific techniques and inputs from the industrial sector.

5. Since 1968, China's grain production has grown at only 0.9 percent annually. The stagnation after 1968 suggests that more advanced technologies were not available. Modern agriculture is like a treadmill: new techniques must be constantly devised and extended as higher production is required, as inputs change and as new pests and diseases emerge. China successfully mounted this treadmill in the early and mid-1960's, but by the end of the 1960's China may have had difficulty staying on the treadmill. (It should be pointed out that there is also the possibility that the lower growth rates reflect a statistical problem; perhaps

---

[7] This is an extremely high rate of growth to be sustained over several years. Often such a rapid growth rate in agricultural production might be related to bad weather in the first year of the series and good weather in the last year. In addition, some error may be introduced by the Chinese practice of rounding their estimates to two significant digits. Despite these potential sources of error, I believe the data are basically correct in suggesting that grain production grew very rapidly in this period.

during the 1960's the definition of "Unified Grain Equivalent" changed; moreover, perhaps after the Cultural Revolution it was more feasible for production units to fail to report, i.e., to hide, some of the grain.)

This data on grain production shows very rapid growth in the early and mid-1960's. The following section shows that important improvements were made in agricultural techniques at that time to make much of this growth in production possible.

II. Adoption of Modern Agricultural Inputs

In China there are two slogans which summarize the combination of technological changes that must be made for agricultural development. One is the "Eight Character Charter," which lists (1) land construction and rearrangement, (2) water control and irrigation, (3) fertilizer, (4) improved varieties of seeds, (5) pest control, (6) improved field management, (7) better farm tools, and (8) close planting. A second slogan refers to the "Four Changes," namely, electrification, irrigation, chemicalization, and mechanization. These technological changes are not unique to China; they form the core of modern agriculture anywhere.

In the following section, Chinese reports on adoption of these modern agricultural inputs show that about one dozen areas ("high and stable yield areas"), covering roughly 20 percent of China's cultivated area (as summarized in Table 1), received a full complement of modern inputs, and developed modern agriculture in the early and mid-1960's. In other regions of China agriculture has advanced too, but not as comprehensively.

A. Mechanization of Irrigation

One dimension of technical change in China's agriculture was the mechanization of irrigation. From 1957 to 1965, mechanical irrigation equipment rose from 0.56 million horsepower to 8.6 million horsepower.[8] This equipment was used on about 6.6 million hectares of land in 1965.[9] (At that time China had about 32 million hectares of irrigated land, four-fifths of which was irrigated by gravity-fed systems or hand wells and pumps.[10]) Most of the mechanical irrigation equipment was used near urban concentrations to assure a high and steady yield of grains and vegetables. As seen from Table 5, regions around the major urban areas of Peking, Shanghai, Canton, and Szechwan had over 80 percent of the mechanically irrigated area in 1965.

Mechanical irrigation continued to increase after 1965, rising to about 12 million horsepower in 1971.[11] If each horsepower irrigated the same number of hectares in 1971 as in 1965 (0.8 hectares), then about 9 million hectares were mechanically irrigated in 1971.

Several other areas developed smaller mechanical power irrigation systems. An irrigation network was begun in the area around Wuhan in the early 1960's. The project was planned to provide

---

[8]Chinese data is conveniently summarized by Kang Chao, op. cit., p. 141.

[9]"How China Achieves Good Harvest in 1965," NCNA Peking, December 28, 1965. SCMP 3609, p. 24.

[10]Chao, op. cit., p. 124.

[11]"Agricultural Development," Peking Review, No. 45 (November 10, 1972), p. 45 stated that from 1962 to 1971, irrigation and drainage machinery had trebled. A figure for 1962 is available in Chao, op. cit., p. 141.

Table 5

Major Mechanical Irrigation Systems, 1965

Region	Million Hectares
1. North China Plain, mechanical wells in the Peking-Tientsin area	1.3[a]
2. Lower Yangtze, near Shanghai	3.1[b]
3. Pearl River Delta, south of Canton	0.4[c]
4. Szechwan (1966)	0.6[d]

Sourcet

[a]"Medium and Small Factories Serve Agriculture in North China,t' NCNA Tientsin, September 7, 1964. SCMP 3316, p. 12.

[b]"More Electricity for People's Communes in China,t' NCNA Peking, April 24, 1964. SCMP 3208, p. 16. "Electric Pump Operators and Tractor Drivers Trained for China's Rural Areas,t' NCNA Peking, January 10, 1963. SCMP 2898, p. 13. "China Uses More Pumps for Irrigation and Drainage,t' NCNA Peking, April 3, 1963. SCMP 2955, p. 15.

[c]"Fifth Year of Construction on Pearl River Delta Pumping Stations,t' NCNA Canton, October 23, 1964. SCMP 3326, p. 19.

[d]"China's Leading Rice Producing Province Makes Headway in Technical Transformation of Agriculture,t' NCNA Chengtu, October 24, 1966. SCMP 3809, p. 27.

irrigation and drainage for 0.13 million hectares.[12] A large network of pumps was planned around the Tungting Lake of Hunan.[13] Plans were also announced for large irrigation systems in the northeast provinte of Kirin, near Changchun.[14] Another area where

[12]"New Electric Pumping Projects in Central China, Yangtze Provtnce,t' NCNA Wuhan, January 9, 1963. SCMP 2897, p. 13. "Big Power Transmission Project for Central China Rural Area," NCNA Wuhan, July 26, 1964. SCMP 3269, p. 17.

[13]"Electric Pumps in Central-South China Province,t' NCNA Changsha, August 4, 1964. SCMP 3275, p. 21. "Tungting Lake Today," China Reconstructs, XXII (10) (October 1973), pp. 2-6.

[14]"New Pumping Stations in Northeast China,t' NCNA Changshun, August 26, 1964. SCMP 3290, p. 14.

machinery has increased irrigation is in Honan, particularly around the cities of Chengchow and Loyang. Between 1965 and 1971, mechanical wells in Honan increased from 10,000 to 260,000 and irrigated acreage rose from 1 million hectares to 2.66 million hectares.[15]

Mechanization of irrigation is a crucial step in improving agricultural production. Assuming the water source is adequate, mechanization guarantees production in time of drought. If there is flood, the same equipment can also be used for drainage. Mechanization of irrigation permits the precise regulation of water supplies required by high yielding varieties of rice. Finally, it makes multiple cropping possible in areas where supply of water at specific times was a bottleneck. A Chinese slogan summarizes the crucial role of irrigation and drainage: "Water conservancy is the lifeline of agriculture."

B. Seeds

Throughout Asia new seeds--"miracle rice" and "miracle wheat" --have become synonymous with agro-technical transformation. The great advantage of these varieties of seeds (especially of rice) is that they remain responsive to fertilizer at high rates of application. This is because the varieties are short and strong, and do not fall over (lodge) when they grow a lot of grain. In China, similar varieties of rice and other crops has played an important role in agricultural development.

---

[15] Rewi Alley, "A Glimpse at Today's Chengchow," Ta Kung Pao (Hong Kong) July 6, 1972, p. 13.

1. Rice

During the early 1960's, very high yielding varieties of rice and wheat were developed and popularized, especially in the "high and stable yield" areas which had good, mechanized irrigation. By 1965 about 4.3 million hectares of high yielding rice and about 2.5 million hectares of high yielding wheat were planted.[16]

The high yielding rices were called nung-k'en 58, chen-chu-ai, ai-chiao-nan-t'e and kuang-ch'ang-ai. These new varieties of rice distributed in 1964 and 1965 were similar to those of "miracle rice" distributed by the International Rice Research Institute, Philippines, in 1966. The Chinese varieties are short stalked and less likely to lodge in time of heavy winds or when heavily fertilized. Chinese agronomists described them this way:

> The short stalk varieties, in general, are characterized by such features as short notches, powerful tillering, short and straight leaves, good light infiltration in clusters, and well-developed roots. The combination of these features constitute the high-yield characteristics of absorption of fertilizer, resistance to lodging, and greater numbers of earings.[17]

We should note that descriptions of IRRI seeds are quite similar:

> IR8 has excellent seedling vigor and produces moderately high number of productive tillers with short, sturdy stems . . . t . It is resistant to lodging at high rates of nitrogen fertilization . . t . The variety is reasonably resistant to most common diseases of rice.

---

[16] Sources for these figures are given later in the text.

[17] Rice Scientific Technical Group of the Chinese Academy of Agricultural Sciences, "Preliminary Summary of the Cultivating Techniques in the 1965 Bumper Rice Harvest in the South," Chung-kuo Nung-yeh K'o-hsüeh (Chinese Agricultural Science), No. 2 (February 1966), JPRS 36, 217, p. 3.

> IR5 . . . has excellent seedling vigor, erect leaves, and high tillering ability. However, it is taller and is more prone to lodge at high fertility levels than IR8 . . . . It is somewhat susceptible to blast and bacterial leaf blight, however.[18]

As should be expected, the yield of the high yielding varieties depended on cultivation practices. Under ideal conditions, the new varieties could yield up to 7.5 tons per hectare,[19] about the same as IR8. When cultivated without necessary inputs the yield might be only 1.5 to 2.25 tons per hectare.[20] The average yield of traditional varieties under normal cultivation is also variable, around 2 tons per hectare.[21] Thus the new varieties had the genetic potential for almost quadrupling yields.

In actual use, of course, the results were not that dramatic. Areas that adopted new varieties in 1965 showed increases in yields of roughly 0.37 to 0.75 tons per hectare; sometimes the increase was as high as 1.5 to 2.2 tons per hectare.[22]

Spotty reports from a variety of places in south China agree with the reports of the Chinese agronomists. In the early 1960's typical yields were 1.9 to 2.3 tons per hectare per crop. In the

---

[18] University of Philippines, College of Agriculture, Rice Production Manual (University of Philippines, 1970), p. 41.

[19] Rice Scientific Technical Group of the Chinese Academy of Agricultural Sciences, op. cit., p. 1.

[20] Ibid., p. 4.

[21] For example, the average grain yield in Kwangtung in 1957 was 1.8 tons per hectaret Szechwan had an average yield of 2.1 tons per hectare sown to grain. See Chao, op. cit., p. 301.

[22] Rice Scientific Technical Group of the Chinese Academy of Agricultural Sciences, op. cit., p. 3.

late 1960's, after new varieties had been popularized, typical yields were 2.6 to 3.0 tons per hectare.[23]

While the Chinese rice varieties could raise yields, they also had some shortcomings (similar to those of the IRRI varieties). First, the new Chinese varieties required complementary inputs, especially of fertilizer and water. If they were cultivated in less fertile farmland without complementary inputs, they might yield less than the traditional varieties under the same conditions. This was specifically reported for nung-k'en 58.[24] A second problem encountered was that some of the early high yield varieties (for example, ai-chiao-nan-t'e) could not be utilized in double cropping regions of Central China effectively because they took too long to mature and interfered with the planting of a second crope[25] A final problem had to do with resistance to diseases. Chinese agronomists pointed out that the new varieties "showed an early weakening of stalks and leaves, as they were also vulnerable to banded sclerotial disease, bacterial leaf blight, and pestalotia leaf spot,"[26] (as is IR5).

As for taste and cooking qualities of the Chinese high yield varieties, it was reported that nung-k'en 58 was "soft and good for cooking,"[27] but the same was not claimed for the other high

---

[23]These figures come from interviews on file in the Contemporary China Reading Room, Columbia University.

[24]Rice Scientific Technical Group of the Chinese Academy of Agricultural Sciences, op. cit., p. 4.

[25]Ibid.

[26]Ibid.

[27]Agricultural Technology Promotion Station, Pao-shan hsien, Shanghai, "Our Experience in Planting Nung-k'en 58 Late Rice," Nung-yeh Chi-shu (Agricultural Technology) No. 10 (October 1964). JPRS 43, 378, p. 43.

yield varieties that were widely popularizede Some informants reported that the newer varieties were not prefered for consumption, and generally the production units sold the new varieties to the state, retaining more traditional varieties for local consumptione

The high yielding varieties required very precise field management to show improved yield. The Chinese developed many slogans to summarize the field management techniques of these seeds. For example, one management method was called the "three-early, one skillful" method. This required early application of fertilizer, early raking of the field, insect control, and skillful irrigating.e[28] Another method was the "three-determination and four-observation method." This called for determining the amount of fertilizer, the kind of fertilizer, and the time of applying, and observing the weather, soil, sprout and strain of rice conditions.[29]

To get high yields (up to 6.4 tons per hectare) Chinese agronomists recommended rather dense planting. The suggestions for areas with adequate water, fertilizer and labor power are summarized in Table 6.

The very high yielding varieties of rices were reported expanded by 3.3 million hectares in 1965.[30] If we assume arbitrarily

---

[28]Scientific Experimental Group, Miao-erh-ch'iao Brigade, Kung-tung Commune, Huang-yen Hsien, Chekiang, "Manage Properly the Nung-k'en 58 Consecutive Late Rice Crop by 'Three-early and One-skillful' Method," Nung-yeh Chi-shu (Agricultural Technology), No. 8 (August 1966)e, JPRS 38, 826, p. 11.

[29]Li Shao-ch'iu, Nei-p'an Brigade, Tung-feng Commune, Ch'ao-an Hsien, Kwangtung, "The Technique of Applying Fertilizer by 'Three-determination and Four-observation' Adopted by Nei-p'an Brigade for Consecutive Late Rice Crop," Nung-yeh Chi-shu (Agricultural Technology), No. 8 (August 1966), JPRS 38, 826, p. 11.

[30]Rice Scientific Technical Group of the Chinese Academy of Agricultural Sciences, op. cit., p. 3.

Table 6

Recommended Planting Densities for New Rice Varieties

Seed	Clusters per Ha.	Shoots per Ha.	Stalks per Ha.	Ears per Ha.
chen-chutai		1,500,000	5,250,000	3,750,000
		1,200,000-1,500,000	3,750,000-4,500,000	2,700,000-3,000,000
lao-lai-ching	300,000	1,500,000		2,250,000-2,400,000
nung-k'en 58		1,500,000-1,800,000		3,900,000-4,200,000

Source: Rice Scientific Technical Group of the Chinese Academy of Agricultural Sciences, "Preliminary Summary of the Cultivating Techniques in the 1965 Bumper Rice Harvest in the South," Chung-kuo Nung-yeh K'o-hsüeh (Chinese Agricultural Science), No. 2 (February 1966), JPRS 36, 217, p. 11.

that 1 million hectares were planted to very high yielding varieties in 1964 (we know at least 0.64 million hectares were planted to 3 varieties), then we can estimate the acreage planted as about 4.3 million hectares. This represents about 13 percent of the total area sown to rice (about 32 million hectares). Specific figures available for popularization of three of the varieties are given in Table 7.

Popularization of these varieties was especially rapid in the important rice grainary of Kwangtung province (latitude 23°). About 1.5 million hectares of new varieties of rice were sown in Kwangtung in 1965. This constituted two-thirds of the early crop there. The seeds used in Kwangtung were chen-chu-ai, kuang-ch'ang-ai, ai-chiao-nan-t'e, and chiang-nan-ai. Although these seeds were found successful on the early crop, they were not suitable for the late crop. Only two percent of the late crop was planted

Table 7

Extension of Specific Varieties of Very High Yield Rice

Variety	Amount planted in 1964 million Ha.	Amount planted in 1965 million Ha.	Where Used
nung-k'en 58	0.27	1.13	Yangtze Valley
chen-chu-ai	0.04	0.73	Kwangtung
ai-chiao-nan-t'e	0.33	0.73	Kwangtung
Others	0.36*	1.71	

Source: Rice Scientific Technical Group of the Chinese Academy of Agricultural Sciences, "Preliminary Summary of the Cultivating Techniques in the 1965 Bumper Rice Harvest in the South," Chung-kuo Nung-yeh K'o-hsüeh (Chinese Agricultural Science), No. 2 (February 1966), JPRS 36, 217, p. 3.

*Estimated on the assumption that one million hectares were planted to new varieties in 1964.

totthese varieties.[31] Former residents report that the new varieties continued to be extensively used in the late 1960's.[32]

In Kiangsu (latitude 32°) 0.63 million hectares were planted to nung-k'en 58 in 1965,[33] and 0.08 million hectares were planted to other varieties in the nung-k'en series, especially nung-k'en 57, 46, and 44.[34] These four varieties of nung-k'en seeds were

[31] Kwangtung Academy of Agricultural Science, "A Basic Summary of the Work of Breeding Seedlings of Low-Stalk Strains of Rice in Kwangtung," Kuang-tung Nung-yeh K'o-hsüeh (Kwangtung Agricultural Science), No. 1 (February 1966), JPRS 36, 710, p. 1.

[32] Interviews on file in Contemporary China Reading Room, Columbia University.

[33] "Some Problems of the Main Characteristics and the Planting of Nung-k'en 58 Strain of Late Rice," Chiang-su Nung-hsüeh-pao (Kiangsu Agricultural Journal), Vol. 5, No. 2 (April 1966), JPRS 38, 022, p. 1.

[34] "A Preliminary Summary of Planting Techniques for the High Yield of Nung-k'en 57, Nung-k'en 46 and Nung-k'en 44 of Middle Non-glutinous Rice," Chiang-su Nung-hsüeh-pao (Kiangsu Agricultural Journal), Vol. 5, No. 2 (April 1966), JPRS 38, 022, p. 3.

planted on about 9 percent of the area sown to grain, and other new varieties were planted also.

In Fukien (latitude 26°) 0.33 million hectares were planted to new varieties in 1965.[35] This represented about 17 percent of the area sown to grains. In 1971 it was reported that 0.6 million hectares had "high and stable" yields.[36]

In Hunan (latitude 28°) by 1965, 45 percent of the early rice and about 60 percent of the late crop was planted with improved seeds which yielded 10 to 30 percent more.[37] A late-rice yielding 7.5 tons per hectare was developed and popularized in Hunan in 1971.[38]

In the important rice basket of Szechwan, new high yield varieties were successfully tested in 1964, but there are no reports that show widespread adoption after 1965.[39] However, given the extensive expansion of mechanized irrigation there, it can be presumed that high yielding varieties have been popularized.

Very high yielding dwarf-rice varieties were also reported under cultivation in Yunnan, Kiangsi, Kwangsi and Kueichou, but

---

[35] "Archetype Paddies Boost General Early Rice Crop Yield in Fukien," Chung-kuo Hsin-wen (China News Bulletin), Canton, September 23, 1965. JPRS 32, 516, p. 6.

[36] "China's 1971 Achievements in Water Conservancy," Economic Reporter (English Supplement), January-March 1972, p. 14.

[37] "Good Rice Strains Used Widely in Central South China," NCNA Changsha, August 2, 1965. SCMP 3512, p. 20.

[38] "Peasant Technicians," Peking Review, No. 49 (December 8, 1972), p. 23.

[39] Szechwan Agricultural Science Academy, "Experience on Bringing About High Yield in Rice Crop Cultivation," Chung-kuo Nung-yeh K'o-hsüeh (Chinese Agricultural Science), No. 2 (February 1965), JPRS 31, 556, pp. 8-20.

Table 8

Local Adaptations of High Yielding Rice Varieties

Place	Basic Strain	New Strain
Kwangsi	nan-kao-kung	kuang-hsuan 3
Chekiang	ai-chiao-nan-t'e	ai-nan-tsao 1
Fukien	ai-chiao-nan-t'e	mei-feng 3
Szechuan	nung-k'en 58	cheng-tu-ai 3
Shanghai	nung-k'en 58	hu-hsuan 17
		hia-hung 08
Kiangsu	nung-k'en 58	chih-ma-tao
		yeh-li-ching

Source: Rice Scientific Technical Group of the Chinese Academy of Agricultural Sciences, "Preliminary Summary of the Cultivating Techniques in the 1965 Bumper Rice Harvest in the South," Chung-kuo Nung-yeh K'o-hsüeh (Chinese Agricultural Science), No. 2 (February 1966), JPRS 36, 217, p. 4.

the amount planted was not reported.[40]

The Chinese seed development program encouraged local adaptation of seeds, so that new varieties would be developed for the needs of each locality. This was necessary in a country as large and diverse as China. Table 8 shows some of the major adaptations that were made to the high yielding varieties presumably around 1964.

2. Wheat

With regard to high yielding wheat varieties, considerable progress was made during the 1960's. In 1965, 2.5 million hectares were planted to improved wheat strains[41] (out of a total 26 to 32

[40] Rice Scientific Technical Group of the Chinese Academy of Agricultural Sciences, op. cit., p. 2.

[41] "Mass Seed Selection Underway in China," NCNA, Peking, June 17, 1965. SCMP 3482, p. 15.

million hectares planted to wheat).[42] The new strains were reported in use (or under experimentation) in Honan, Shensi, Hopei, Szechwan, Shuntung and Shansi. Early and intensive experimentation with improved wheats was done in the Peking suburbs, where 87,000 hectares are planted to wheat.[43] It was reported that already by 1964, 90 percent of these lands were sown to good strains.[44] Production in 1964 was 50 percent higher than the previous year.[45]

In addition to high yield, the Chinese varieties of improved wheat are disease resistant and adaptable to local cultivation requirements. For the Peking area, pei-ching 8 was recommended, which could yield 3.0 to 3.75 tons per hectare and was early maturing and rust resistant in the irrigated areas in that locality.[46] Other improved wheat seeds in the Peking area were nung-ta 3, 9, 183 and 90.[47]

---

[42] U. S. Government estimates total area sown to wheat is 26 million hectares. Current Scene, Vol. VII, No. 6, p. 9. FAO estimates 32 million hectares. Production Yearbook 1971 (Rome: FAO, 1972).

[43] Wheat Team of the Peking Municipal Crops Institute, "Analysis of the Technical Experiences of the Wheat Experimental Farms in Peking Suburbs in 1964," Chung-kuo Nung-yeh K'o-hsüeh (Chinese Agricultural Science), No. 9 (September 1964), JPRS 30, 055, p. 10.

[44] "Advanced Farming Technique Trebles Wheat Output Around Peking," NCNA Peking, January 20, 1964. SCMP 3145, p. 18. "Good Wheat Strains Widely Used on Outskirts of Peking," NCNA Peking, January 8, 1964. SCMP 3137, p. 15.

[45] Wheat Team of the Peking Municipal Crops Institute, op. cit., p. 10.

[46] Jen Hsiao-p'ing, "A Good Seed Planted Will Yield a Thousand Good Grains for Food," Hsüeh K'o-hsüeh (Study Science), No. 8 (1964), JPRS 29, 641, p. 63. Tai Sung-en, "Mass Efforts to Extend Improved Seed," China Reconstructs, April 1966, p. 19.

[47] Sung Ping-i, of Tung-pei-wang Commune, Peking, "Experiences of the Breeding of Better Wheat Strains of Tung-pei-wang Commune," Chung-kuo Nung-yeh K'o-hsüeh (Chinese Agricultural Science), No. 10 (October 1964), JPRS 44, 560, p. 11.

For Shantung, chi-nan 2 was suggested. It yielded roughly 20% more than other widely used varieties.[48]

For the Yangtze valley area, hua-nan 6 was suggested. A test plot yielded 2.5 tons per hectare. Because of its resistance to rust and early maturing characteristics, it was suggested for intercropping with rice.[49]

For Szechwan and the Yangtze valley, shan-nung 205 was recommended. Yields on test plots were from 2.7 to 4.6 tons per hectare. This variety was resistant to rust, black mottle of the ears, drought and cold.[50]

During 1972 another new variety of wheat, tung-fang-hung 3, was used in demonstration plots near Peking with yields up to 6 tons per hectare. A similar variety was in use in Chengchow.[51]

3. Other Crops

An important grain crop in some parts of northern China is kaoliang (sorghum). According to U. S. government estimates, in the late 1950's about 6 million hectares were planted.[52] The three provinces of the Northeast (Heilungkiang, Kirin, and Liaoning, at latitudes 41°-45°) account for about 35% of the area planted to sorghum.[53] Average yields ranged from 1.2 to 1.6 tons per hectare

---

[48] Jen Hsiao-p'ing, op. cit., JPRS 29, 641, p. 62.

[49] Ibid., p. 61.

[50] Ibid., p. 62.

[51] These were observed by the author when he visited China in Spring 1972.

[52] Agricultural Acreage in Communist China, 1949-68: A Statistical Compilation (n.p.: n.p., 1969).

[53] Ibid.

in this region during the 1950's.[54]

It is difficult to estimate how much progress has been made with regard to sorghum, but new seed varieties have been widely introduced. During the 1930's, the University of Nanking developed strains yielding 1.8 to 2.4 tons per hectare at latitudes roughly 35°-38°.[55] During the 1950's and 1960's, Chinese scientists continued efforts to improve sorghum. In Shansi (latitude 38°) experimental planting of a new type (i-tsa 10) increased yields from 5.4 tons per hectare to 8.6 tons per hectare.[56] In 1972 there was a report of a new hybrid variety capable of yielding up to 15 tons per hectare.[57]

To what extent such high yielding varieties have been extensively planted is not known. It was reported that a new variety of sorghum was planted on about 53,000 hectares in Liaoning (latitude 42°) in 1966--this constituted about 10% of Liaoning's sorghum area. It was reported that yields were improved from 50% to 100%. The average yield on one large test area was 3.7 tons per hectare. This variety was developed through open pollination, and required large complementary inputs of water and fertilizer.[58] By way of

[54] Nai-ruenn Chen, Chinese Economic Statistics (Chicago: Aldine, 1967), pp. 321-23.

[55] H. H. Love and John Reisner, The Cornell-Nanking Story (Ithaca, New York: Cornell International Agricultural Development Bulletin 4, 1964), p. 36.

[56] Wang Hung-niu, "Listen to Chairman Mao's Words, Sow and Plant Carefully the 'I-tsa No. 10' Kaoliang," Nung-yeh Chi-shu (Agricultural Technology), No. 3 (March 1967), JPRS.

[57] "Books on Science and Technology," Peking Review, No. 4 (January 28, 1972), p. 23.

[58] "Scientist Attributes His Success in Seed Breeding to Collaboration with Peasants," NCNA Shenyang, May 17, 1966, SCMP 3702, p. 18. "New Sorghum Strain for Northeast China Province," NCNA Shenyang, April 1, 1965. SCMP 3432, p. 17.

comparison; it might be pointed out that a Canadian seed company offers a sorghum variety that will yield, under favorable conditions, 9 tons per hectare at roughly the same latitude as much of China's sorghum area.[59]

As for high yielding maize, only a small amount of data is available. About 27,000 hectares in Shensi were planted to hybrid maize in 1964. It was also reportedly used in Shantung. In both provinces it seems that the hybrid maize was planted for experimental purposes, and was not in general production.[60]

C. Chemical Fertilizer

Before 1960, almost all of the crop nutrients in China came from traditional sources of fertilizer: manure, nightsoil, river and lake mud, and green manures. During the 1960's, there was a basic change in the fertilizer situation; by 1972 chemical fertilizer supplied between 23 and 37 percent of total crop nutrients. All indications are that chemical fertilizer will continue to grow in importance throughout the 1970's, because China has contracted for ammonia factories that will increase nitrogen capacity by two-thirds.

It is not simple to compute the availability of crop nutrients in China because the Chinese report production only in terms of gross output, and do not (as most other countries do) specify what chemicals are produced, or how much plant nutrients are produced. The Chinese do, however, report production according to the size

---

[59] Pride Cornett, Fall 1973, p. 12.

[60] Li Ching-hsiung, "Hybrid Maize Thrives on Commune Farms;" China Reconstructs, No. 11 (1964).

of factory, and this can be used to estimate crop nutrient production. Table 9 summarizes the trends in production of nitrogen and phosphate in different size factories. To estimate the amount of plant nutrients supplied by chemical fertilizer, we make the following assumptions. First, we assume that the large chemical fertilizer factories produce some fertilizer with a high percentage of crop nutrients. This would include urea (52% N), ammonium nitrate (35% N) or concentrated superphosphates (47%-65% P). The greater part of their production is fertilizers with a lower percentage of nutrients, such as ammonium sulfate (21% N) and superphosphates (16-20% P). We will presume that the average plant nutrient content of all fertilizers produced in big factories is 25%. It can be assumed that the small nitrogenous fertilizer factories produce ammonium bicarbonate (17 percent N) by a process developed in 1963.[61] Small phosphate plants can be assumed to produce fertilizer averaging 10 percent of plant nutrient. Imports (assumed to be at the 1970 level) are reported in terms of ammonium sulfate (20 percent nutrient) equivalent. These assumptions are used in calculations shown in Table 10, which concludes that about 4.52 million tons of plant nutrient were available for China's 120 million hectares of cultivated land. This means that in 1972, chemical fertilizer supplied 38 kilograms of plant nutrient per hectare of cultivated land in China. This is far less than Japan (720 Kg./Ha.) or Taiwan (254 Kg./Ha.) but higher than most other Asian countries. In Table 11, computations are made to ascertain the significance of 4.52 million tons of nutrients compared to traditional

---

[61] Leslie T. C. Kuo, The Technical Transformation of Agriculture in Communist China (New York: Praeger, 1972), p. 105.

Table 9

Domestic Production of Chemical Fertilizer
(million tons)

Type of Factory	1964	1965	1971	1972
Large Nitrogen	2.0		2.0	2.1
Small Nitrogen	0.5 } 1.8	1.1	7.2 } 10.0	9.9
Small Phosphate	1.3		2.8	3.0 } 7.9
Large Phosphate	2.1		4.9	4.9
TOTAL	5.9	8.9	16.9	19.9

Sources

The figures in the above table that are underlined were given in fairly direct terms by Chinese statements, as detailed below. Other figures in the table were computed or estimated.

Total Production:

1964, 1965: Kang Chao, Agricultural Production in Communist China, 1949-65 (Madison: University of Wisconsin Press, 1970), p. 315.

1971: Chou En-lai told Edgar Snow that 1970 production was 14 million tons. Edgar Snow, "Talks with Chou En-lai: The Open Door," New Republic, Vol. 164, No. 13 (March 27, 1971), p. 20. It was reported that 1971 production went up 20.2%. "New Leap in China's National Economy," Peking Review, No. 2 (January 14, 1972), p. 7.

1972: Production grew 18%. "Industrial and Transport Achievements," Peking Review, No. 3 (January 19, 1973), p. 5.

Small Factories, both nitrogenous and phosphate

1964: They produced 30% of the total fertilizer (1.8 million tons), Economic Background, March 14, 1965.

1971: They produced 60% of the total fertilizer (10.0 million tons), "New Leap in China's National Economy," Peking Review, No. 2 (January 14, 1972), p. 8.

Small nitrogenous factories

1965: They produced 12.4% of the total output (1.1 million tons), Ta Kung Pao, June 15, 1966.

1971: They produced 43% of national output (7.2 million tons), "Fertilizer Production Climbs Steadily," Peking Review, No. 44 (November 3, 1972), p. 29.

1972: They supplied over 50% in 1972 (over 9.9 million tons), "Industrial and Transport Achievements," Peking Review, No. 3 (January 19, 1973), p. 5.

Phosphate fertilizer, both large and small factories

1972: Phosphates made up about 40% of total output (7.9 million tons), "Industrial and Transport Achievements," Peking Review, No. 3 (January 19, 1973), p. 5.

Table 10

Availability of Chemical Fertilizer and Plant Nutrients
1972

Source of fertilizer	Amount (million tons)	% Nutrient	Total plant nutrients (million tons)
Large nitrogen factories	2.1	25	0.52
Small nitrogen factories	9.9	17	1.68
Small phosphorous factories	3.0	10	0.30
Large phosphorous factories	4.9	25	1.22
Imports	(4.0)	20	0.80
TOTAL	23.9		4.52

Table 11

Various Computations for Source of Crop Nutrients
1972

	Crop nutrients from traditional fertilizer (million tons)	Crop nutrients from chemical fertilizer	Total	Percent of crop nutrients from chemicals
high estimate[a]	14.80	4.52	19.32	23
low estimate[b]	6.07	3.63	9.69	37

Sources:

[a]This is computed by using figures from Shigeru Ishikawa, Factors Affecting China's Agriculture in the Coming Decade (Tokyo: Institute of Asian Economic Affairs, mimeo, 1967), p. 59 for 1965, and then assuming an annual growth of 2 percent.

[b]This is computed according to the method of Kang Chao, Agricultural Production in Communist China, 1949-1965 (Madison: University of Wisconsin Press, 1970), p. 150. Chao's figures have been modified to take into account growth in population and animal husbandry which directly affect supply of nightsoil and manures. These figures are lower than others because they consider plant nutrients which are actually absorbed by the plants, not the total supply of nutrients.

sources of fertilizer in China. Various estimates show traditional fertilizers supplied from 6.07 to 14.80 million tons of crop nutrients. Thus chemicals supply somewhere between 23 and 37 percent of total crop nutrients.

Including both traditional and chemical sources of fertilizer, China had perhaps as much as 160 kilograms of crop nutrients available per hectare of cultivated land in 1971, or around 110 kilograms per crop hectare (assuming that natural fertilizers were used at the same rate as in the 1950's). By way of comparison, in 1962 Japan utilized about 204 kilograms of crop nutrient per crop hectare, roughly twice what China used.[62] Since Japan's agricultural development has stressed increases in yields through high applications of chemical fertilizer, this figure represents sort of a maximum utilization rate for chemical fertilizer. Thus, although China has made a great change in the source of fertilizers and the level of applications, there is room for continued improvement.

There are clear indications that there will be continued expansion of the chemical fertilizer industry and change in its structure. In December 1973, it was announced that China had contracted with the U. S. Kellogg Corporation, a Dutch firm, and a Japanese firm to purchase ten large ammonia factories which would go into production in the mid- and late 1970's. These factories will be able to produce 3.0 million tons of nitrogen per year, thereby raising China's supply of crop nutrients by about 65% over the already high 1972 level. In addition, China purchased eight

---

[62] Dawson, op. cit., p. 115.

Table 12

Chinese Contracts for Chemical Fertilizer Factories, 1973

Product	Number of factories	Capacity of each	Gross yearly capacity (million tons)	Percent nutrient	Total crop nutrient (million tons)
Ammonia	10	1,000 tons/day	3.65	82	3.00
Urea	8	1,620 tons/day	4.75	52	2.47

Source: New York Times, November 28, 1973.

urea factories (which will be the largest in the world), presumably to convert the ammonia of these factories into a fairly concentrated, easily transported solid fertilizer.

The purchase of these very large factories marks an important break in industrial development strategy for China. Since the mid-1960's, virtually all the growth in nitrogenous fertilizer had been in the production of small factories. These small-scale factories were undoubtedly linked with broad policies to develop local and regional self-sufficiency in case of war or natural disaster, to equalize distribution of fertilizer factories, and to reduce the transportation expenses that would have been incurred if production had been concentrated in a few urban centers. These small factories were generally presumed by western engineers to be sacrificing great economies of scale in nitrogen production, but no one could be certain as the technical details for the small nitrogenous fertilizer factories were unknown. The purchase of the large factories, however, suggests that the earlier small factories were substantially less economical in producing fertilizer, and that the Chinese leadership is now more willing to promote some degree of centralization in this industry.

The utilization of chemical fertilizers is somewhat concentrated in the "high and stable yield areas." The overall availability of chemical fertilizer averages out to 18 catties per sown mou (135 kilograms per hectare gross weight of fertilizer), or 24 catties per cultivated mou for 1971. We know that some communes in the Peking and Canton suburbs reported using in excess of 100 catties per mou of chemical fertilizer (0.75 tons per hectare).[63] Since we have estimated that China had about 9 million hectares with mechanized irrigation, if all of this area received this high level of fertilizer, then it would have utilized about one-third of the total consumption of China in 1971, 6.75 tons of fertilizer. The remaining two-thirds (14 million tons) would then havetbeen distributed throughout the rest of the country at an average availability of 20 catties per mou (0.14 tons per hectare). (Presumably there are significant variations in application of fertilizer in these areas.)

One reason that a substantial portion of chemical fertilizer can be distributed broadly throughout the country is that a large percentage of chemical fertilizer is being supplied by small factories which are situated away from major urban centers. The most dramatic source of growth in China's fertilizer industry throughout the 1960's, as can be seen in Tables 9 and 10, is in the development of small nitrogenous fertilizer plants, but this policy appears to be reversed by the purchase of the large factories, as mentioned above. Perhaps one reason for the conversion of the ammonia into urea is to assure that transportation expenses to distant locations will not be very expensive.

---

[63] Response to author when he traveled in China, Spring 1972.

D. Mechanization

Another dimension of technical change in China's agriculture has been mechanization and electrification. By 1971, China had over 207,000 standard (i.e., 15 horsepower) tractors.[64] This should have been enough to cultivate over 20 million hectares of land, representing about 18 percent of the total cultivated area.[65]

Tractors are, in general, concentrated in the northeast sections of China (former Manchuria) and the North China plain. By 1965, about one-third of the land in the Northeast was machine cultivated.[66] The Peking suburbs were also mechanized during the 1960's; by 1966, 60 percent of the suitable land around Peking was machine plowed.[67] Provinces on the North China Plain also

---

[64] Peking Review reported: "Compared with 1962, the number of tractors in 1971 has more than doubled . . . . " Peking Review, No. 45 (November 10, 1972), p. 18. The figure for 1962 is from Chao, op. cit., p. 107. It is not clear whether the statistic for 1971 refers to tractor units or to standard (15 HP) tractors, as does the 1962 statistic. In the text, I have assumed it refers to the standard tractors. If this assumption is incorrect, then the number of standard tractors available in 1971 would be lower than stated, because the large expansion of production of small tractors undoubtedly lowered the average horsepower rating of tractors by 1971.

[65] This estimate is based on two ways of computing. By using the ratio for machine plowing in 1964, the last year for which statistics are available (when 123,000 standard tractors cultivated 10.8 million hectares, according to Chao, op. cit., pp. 107, 115), we find that 18 million hectares should have been plowed. Alternatively, if we use estimates by Chinese economists that one standard tractor should be able to service 100 hectares, then about 21 million hectares should have been plowed by tractors in 1971. The estimates by Chinese economists are available at: Hsiang Nan, "Certain Problems of Agricultural Mechanization," Jen-min Jihepao (People's Daily), December 22, 1962. Also Liu Jih-hsin, "Exploration of a Few Problems Concerning Mechanization of Our Agriculture," Jen-min Jih-pao (People's Daily), June 20, 1963. SCMP 3021, p. 3.

[66] "China Extends Range of Tractors," NCNA Peking, January 31, 1966. SCMP 3631, p. 19.

[67] "Peking and Surrounding Country Districts Develop New Relationship," NCNA Peking, February 7, 1966. SCMP 3635, p. 22.

developed mechanization. Many tractors were reported in Shantung, Shansi, and Hopei.[68] Mechanization proceeded rapidly in the late 1960's. By 1970, 60 percent of the farm land was cultivated by machine in a number of provinces.[69] In 1971, 40 percent of the land in Honan was mechanically tilled.[70]

In the Southern rice paddy areas, mechanization based on small garden tractors began in the mid-1960's. The exact extent of use of garden tractors is not known, but they are in widespread use in suburban communes in Southern China, according to many visitors.

Mechanization of harvesting in China is almost unknown, with the exception of harvesting of wheat on mechanized state farms, mostly in the northeast. Mechanization of grain processing--threshing and milling, for example--is widespread, but again statistics are lacking. In the Pearl River Delta, foot-operated threshing machines are quite widespread.[71] In 1972, China vaguely reported: "In many places more than half the rice harvested is machine-threshed."[72] In Hunan, 80 percent of the rice threshing

---

[68] "East China Province Mechanizing Farming," NCNA Tsinan, October 22, 1963. SCMP 3088, p. 10. "North China Province to Step up Agricultural Mechanization," NCNA Taiyuan, February 16, 1961. SCMP 2442, p. 12. "More Tractors Used in Northern Part of China for Autumn Plowing," NCNA Peking, October 12, 1961. SCMP 2601, p. 6.

[69] Nung Chi-ping, "China is Mechanizing her Agriculture," China Reconstructs, January 1970, p. 11.

[70] Yu Wen, "How Honan Achieves Self-Sufficiency in Grain," Peking Review, No. 40 (October 6, 1972), p. 27.

[71] Interviews available at Contemporary China Reading Room, Columbia University.

[72] "Mechanizing Paddy-Rice Cultivation," Peking Review, No. 42 (October 20, 1972), p. 23.

was mechanized or semi-mechanized by 1973.[73]

For over fifteen years, China has been trying to develop machinery that could transplant rice shoots. Engine driven rice transplanters are used in the Peking suburbs, but it is not known whether they are used for all the rice or only experimentally.[74] In Hunan around 1970, over 13,000 mechanical transplanters were used. (Chuchou County of Hunan had 3,700 for 4,300 hectares.)[75] In Kwangsi, 30,000 transplanters served on 53,000 hectares.[76] In the Pearl River Delta, rice is still transplanted by the traditional hand method.[77]

Generally speaking, mechanization does not have a direct effect on yields in a densely populated country such as China, because enough labor is available to assure intensive cultivation and maximum utilization of available resources. However, mechanization in China (and other Asian countries) can help yields somewhat in certain regions. During the 1950's, surveys of mechanized areas of Heilungkiang, a northeastern province, showed increases in yields of 0.4 tons per hectare due to deeper plowing and more careful cultivation.[78] In addition, mechanization has permitted

---

[73] "Machine-Building Industry," Peking Review, No. 44 (November 2, 1973), p. 22.

[74] Observed by author when he visited China in Spring 1972.

[75] Radio Hunan, July 24, 1970. Also, "Central South China Hsien Makes New Rice Transplanter," NCNA Changsha, October 21, 1968. SCMP 4286, p. 22.

[76] "National Conference on Rice Transplanter Held in Nanning," NCNA Nanning, April 27, 1969. SCMP 4407, p. 21.

[77] Interviews available at Contemporary China Reading Room, Columbia University.

[78] Wang Kuang-wei, "On the Modernization of China's Agriculture," Hsüeh-hsi (Study) No. 1 (January 1958). ECMM 128, p. 34.

expansion of cultivation in underpopulated sections of China's vast northeast and northwest regions. Finally, mechanization can indirectly increase yields in the densely populated southern and central regions by saving time and thus permitting increases in multiple croppingt Aside from these reasons, mechanization has been encouraged as a way of expanding the scale of profitable operations, to make the collective system more sensible and as a way of encouraging rural industrial development.[79]

E. Rural Electrification

Another crude indicator of rural transformation is rural electrification. As late as 1958, rural China consumed virtually no electricity. In 1971, rural consumption of electricity was approximately 9.3 billion kilowatt hours.t[80] I estimate that about one-third of the villages had electricity.

This estimate is based on a variety of reports indicating the extent of rural electrification. In 1963 about 1,000 counties (out of China's 2,100) had some electric power.[81] This rose to 1,300 by 1965.[82] Overall figures for 1972 are not available but it is reported that in Kansu, a relatively backward province in

---

[79] This theme is explored in detail in Benedict Stavis, op. cit.

[80] Rural electrical consumption in 1971 was three times that for 1962. "Agricultural Development," Peking Review, No. 45 (November 10, 1972)t p. 18. The base for 1962 is from Chao,top. cit., p. 141.

[81] "Technical Transformation of China's Agriculture," NCNA Peking, September 30, 1963. SCMP 3074, p. 7.

[82] "The Fine Practice of Operating the Electricity Service in Rural Areas on a Part-Work and Part-Farming Basis," Jen-min Jih-pao (People's Daily) editorial, September 7, 1965t SCMP 3544, p. 12.

the northwest, 41 counties and cities out of 74 had electricity in 1972.[83] Naturally, some provinces are more advanced than others in this respect. In the Southwestern province of Kwangsi, where hydroelectric stations can be set up in many places, it was reported that as early as 1965 all counties had electricity.[84] When electricity is available in the county, however, it is probably available only in the county seat (generally a city with a population of 10,000 to 20,000) and perhaps the adjacent rural areas. In these cases, no doubt most of the electricity is used for governmental communications and small scale industry in the county capitals.

A better indicator of the availability of electrification for agriculture is the number of communes and brigades which have electricity. (A commune might be 100 villages; a brigade is either a village or a group of villages.) At this level, data are sparse but suggestive. In Hopei, a northern province, it was reported that over one-half of the rural communes had electricity in 1963.[85] In 1965, about half the communes throughout the northeast had electricity.[86] In Shansi, also a northern province with a significant industrial base, and where work began on rural electrification

---

[83] "Northwest China Villages Develop Hydro-Electric Power Generation," NCNA Lanchow, March 6, 1972. SCMP 5091-95, p. 147.

[84] "South China Minority Region Gets More Electricity," NCNA Nanning, October 23, 1965. SCMP 3566, p. 23.

[85] "More Electricity for Rural Areas in China's Major Cotton and Wheat Province," op. cit.

[86] "Northeast China Undertakes Electric Pumping Projects on Unprecedented Scale," NCNA Shenyang, April 8, 1965. SCMP 3437, p. 25.

in 1958,[87] 63 percent of the communes and 41 percent of the brigades (which are coterminous with villages in that province) had electricity by 1971.[88]

If about 40 percent of brigades have electricity in a moderately industrialized province, it is a reasonable guess that by 1970, roughly one-third of the villages had electricity. When electricity first comes to a village it is used for agricultural production, that is, for irrigation and food processing. Electricity would also be used in small factories and workshops. Use of electricity for household illumination is a lower priority, but is not ignored. In the electrified areas of the Pearl River Delta and suburbs of large cities, for example, most houses have electric lights.[89] There is no reasonable way to make an estimate of the total number of rural households with electric lights, but it might be one-fifth to one-fourth.

III. Side Effects of Increased Grain Production

Up to this point, we have considered only the changes in grain production, mainly rice and wheat. In terms of cash income to peasants, these increases in grain production have not been very important directly, because the price of grain is kept low. However, once a locality produces enough or surplus grain, it can divert resources (land and labor) to higher-priced subsidiary

---

[87] T'ao Lu-chia, "On T'aiku Hsien's Agro-technical Reform," Hung Ch'i (Red Flag), No. 5 (March 1963). SCMM 359, p. 28.

[88] "More Electrification for North China Province Countryside," NCNA Taiyuan, January 20, 1972. SCMP 5065-69, p. 27.

[89] Interviews available at the Contemporary China Reading Room, Columbia University.

crops such as fruits, vegetables, oil and fiber crops, animal husbandry, sericulture, beekeeping, or local handicrafts and industry. As a result, once a locality succeeds in raising grain production, it has the opportunity to raise fairly rapidly the cash income of the farmers.

The significance of diversification can be shown with available data from a few locations. In Lienchiang County, Fukien, income in 1962 was low, averaging ¥360 per family or ¥84 per capita. (The average family had 4.3 members.) In this area, agriculture was not very diversified. Food grains supplied from 60 percent to 75 percent of the income of the production teams. Differences in income between teams were explained largely (over 75 percent) by differences in food grain productivity.[90]

In contrast, in Liuling brigade, Shensi, where agricultural techniques had begun to change by 1961 (there was mechanical irrigation for a collective vegetable plot and there was machine plowing), average collective income was ¥740 per family (about ¥170 per capita), food grains supplied only about 36 percent of the total collective income. Other plant products (fruits, vegetables, and tobacco) supplied 32 percent and animal husbandry supplied 9 percent.[91]

In one commune in Tungkuan County, Kwangtung, where there was extensive mechanization of irrigation and other processes, diversified activities provided the key to rapid growth. From 1957 to

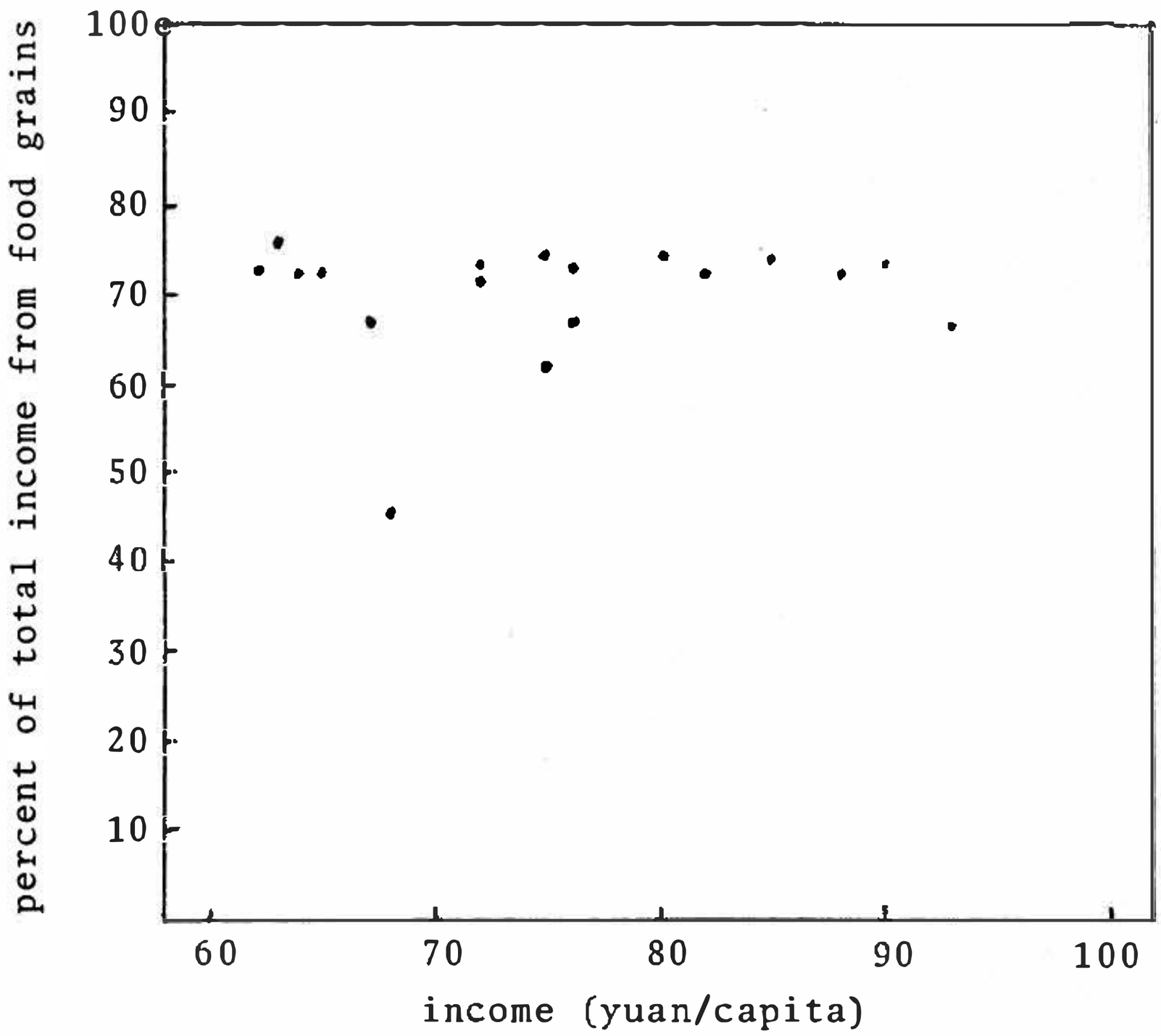
---

[90] "Statistical Tables Relating to the Hu-Li Brigade of the P'u-k'ou Commune," C. S. Chen and C. P. Ridley, Rural People's Communes in Lien-chiang (Stanford: Hoover Institution Press, 1969), pp. 70, 78, 79.

[91] Jan Myrdal, Report from a Chinese Village (New York: Pantheon, 1965), p. 198.

Figure 1

Percentage of Total Income Supplied
by Food Grains in Different Production Teams
of a Poor Commune
(Lien-chiang, Fukien, 1962)



Source: "Statistical Tables Relating to the Hu-Li Brigade of the P'u-K'ou Commune" in C. S. Chen and C. P. Ridley, Rural People's Communes in Lien-chiang (Stanford, California: Hoover Institution Press, 1969), pp. 70, 78, 79.

1964, total collective income went up 2.2 times, with three-quarters of this accounted for by increases in diversified activitiest These activities included animal husbandry (pigs, beekeeping, sericulture, fish farming)t, increased cultivation of non-grain crops (such as peanuts, sugar cane, jute, soya, sesame, bamboo, medicinal herbs, and fruit)t, some manufacturing (of bamboo farm implements, charcoal, bricks, and tile)t, and increase in local food processing.[92] In 1957, grain supplied 55 percent of the commune income; by 1964 grain supplied only 38 percent of commune income.

No national data are available to prove conclusively that agriculture has diversified during the period that grain production went up; or to demonstrate that diversification occurred in localities where grain production reached "high and steady" yields. Thus the preceding analysis is somewhat speculative but such a transformation is clearly the intent of Chinese policy. It means that the benefits of China's green revolution are greater than the simple increases of grain production described above.

IV. Comparison with Other Countries

China's growth rate in food grain production and level of agricultural technology compare favorably with developments in other Asian countries. In an overall sense, China's agriculture is not as advanced as Japan's or Taiwan's. Compared to all other Asian countries, however, China is doing quite well. In terms of production growth, during the 1960's, China's food production has

---

[92] Wang Chen-hua, "Diversified Undertakings Promote Development of Grain Production," Jen-min jih-pao (People's Daily), October 21, 1965. SCMP 3577, p. 15.

Table 13

Indices of Food Production in Less Developed Countries
(1961 to 65=100)

Year	China	South Asia	East Asia
1961	88	99	93
1962	94	97	97
1963	100	102	98
1964	108	104	106
1965	110	98	106
1966	121	96	112
1967	126	106	111
1968	128	114	116
1969	130	121	123
1970	132	127	125

Source: South Asia and East Asia: Montague Yudelman, "The Green Revolution," OECD Observer, No. 52 (June 1971), p. 16, based on United States Department of Agriculture statistics.

China: See above Table 4.

Note: This type of index is strongly influenced by the selection of base years. I do not know about 1961 to 1965 for South Asia and East Asia, but for China this has the effect of selecting for a base the highest level of production attainable under traditional agriculture. For gauging China's changes, it is a good base line. Since there are no concrete data on China's population, no effort has been made to compare food per capita indices.

gone up more than the average of other developing countries in Asia.

In a narrow technical sense, China has made no surprising breakthrough in terms of the theory or practice of agricultural development. The summary of China's agricultural development theory, the "Eight Character Charter," contains no agricultural input that is unknown in other countries. China has, however, been successful in adopting new inputs; the most important of which is fertilizer. Table 15 shows the amount of chemical fertilizer used in China and different Asian countries (in terms of plant nutrients) and the area planted to cereals. China is by

Table 14

Utilization of Chemical Fertilizer (1970)

Country	Area Planted to Cereals (1,000 HA)	Plant Nutrients from Chemical Fertilizer (100 tons) 1970	Plant Nutrients per HA (Kg/HA)
Japan	3,088	21,685	720
Taiwan	1,016	2,566	254
Sri Lanka (Ceylon)	656	937	142
Philippines	5,557	2,566	40
China	118,540	43,610	37
South Korea	2,420	5,631	23
India	103,129	21,773	21
North Korea	2,566	3,335	18
Pakistan	19,501	4,239	15

Source: Production Yearbook, 1971 (Rome: Food and Agricultural Organization, 1972)e

Note: In this table, the comparison is to area planted to cereals, not to total cultivated area, because the former figure gives a better indication of how much land is actually used for basic human survival.

far the largest user of chemical fertilizer in Asia. Japan and India each use, overall, about one-half of what China uses. However, because China has so much land, the amount of chemical fertilizer used per hectare is in the intermediate range. On a per hectare basis, China uses less than Japan, Taiwan, and Sri Lanka (Ceylon), but more than most other Asian countries.

The rate of adoption of high yielding varieties of cereals has been an important aspect of agricultural development in other countries. While our data on China are rather spotty in this regard, the following tables show that through the mid-1960's, China was adopting new seeds (particularly rice) rapidly compared to other countries, though it is not known whether China continued to expand the area of high yielding seeds as rapidly as other Asian countries by the end of the 1960's. It is doubtful that

Table 15

Adoption of High Yielding Wheat Varieties

Country	Area Sown to Wheat (1,000 HA)	Area Sown to HYV Wheat, 1967/68 (1,000 HA)	Area Sown to HYV, 1969/70 (1,000 HA)
India	17,892	2,940 (16%)	6,100 (34%)
Pakistan	6,103	955 (16%)	2,840 (46%)
China	27,500	2,500 (9%)	NA

Table 16

Adoption of High Yielding Rice Varieties

Country	Area Sown to Rice (1,000 HA)	Area Sown to HYV Rice, 1967/68 (1,000 HA)	Area Sown to HYV Rice, 1969/70 (1,000 HA)
Sri Lanka	611	--	26 (4%)
India	38,800	1,780 (5%)	4,370 (11%)
E. Pakistan	9,500	67 (1%)	264 (3%)
W. Pakistan	1,750	4 (--)	500 (29%)
Indonesia	8,466	--	750 (9%)
Philippines	3,159	693 (22%)	1,350 (43%)
China	34,200	4,300 (13%) [1965]	NA

Source: Areas sown to wheat and rice, all countries except China: Production Yearbook, 1971 (Rome: FAO, 1972).

Areas sown to wheat and rice in China: See above Table 2.

Areas sown to HYV wheat and rice, all countries except China: D. Dalrymple, Imports and Plantings of High Yield Varieties of Wheat and Rice intthe Less Developed Nations (Washington: U. S. Department of Agriculture, 1971).

Areas sown to HYV wheat and rice in China: See text above.

China has been as successful as South Asian countries in expanding cultivation of very high yielding wheat strains, and wheat is an important crop in North China, contributing roughly 15 percent of China's food. Perhaps lack of reliable water supplies on the North China plain has slowed popularization of high-yielding wheat. This would appear to be one element of China's agriculture with great potential to increase production.

A water supply that is reliable and accurately controlled is essential to utilize high yielding seeds and chemical fertilizers. In China, we have estimated that by 1971 approximately 9 million hectares were mechanically irrigated and therefore had very precise and reliable control of water. This represented about 20 percent to 25 percent of total irrigated area. Precisely comparable figures are not available for other countries, but there has been a rapid expansion of tubewells in Pakistan and elsewhere to supply water for high yielding varieties. In 1965 in the Indus Basin (West Pakistan) roughly 12 percent of irrigation water was delivered by tubewell.[93]

As for rural electrification, China's progress has been quite rapid, at least compared to India. An estimated one-third of China's villages had electricity in 1970. By way of comparison, in India, 12 percent of the villages had electricity in 1968. (It might be pointed out that there was a great difference between different states in India with regard to rural electrification. In some states 60 to 70 percent of the villages had electricity; in others, only 1 percent had electricity.)[94]

As for mechanization, China is progressing quite well compared to other Asian countries. Japan and Taiwan are more mechanized than China, but in both places mechanization is a relatively

---

[93] Hiromitsu Kaneda, "Mechanization, Industrialization, and Technical Change in Rural West Pakistan," mimeo paper for 28th International Congress of Orientalists, Canberra, January 1971, p. 8.

[94] Usha Dar, "Some Economic Factors in the Expansion of Electricity in the Rural Areas," Indian Journal of Agricultural Economics, Volume 124 (1969), p. 156.

recent development, beginning in the late 1950's in Japan[95] and in the mid-1960's in Taiwan.[96] In Taiwan, in the early 1970's only cultivation is mechanized; transplanting and harvesting were done by hand.

While China used less tractor power per hectare in 1965 than Japan, Taiwan, Sri Lanka, and the Philippines, she was ahead of other Asian countries with regard to mechanization. In West Pakistan, only about 0.1 percent of the cultivated area was plowed by machine in 1965.[97] In that year, about 10 percent of China's cultivated land was machine plowed.[98] Table 17 summarizes data on mechanization. Because of China's increased emphasis on mechanization in the late 1960's and early 1970's, it is probable that later data will show further relative improvement for China in terms of mechanization.

Chinese policy toward mechanization, especially in recent years, has been somewhat like Japan's early policy, in which various operations were mechanized one at a time (for example, threshing or irrigation). Moreover, there was a gradual, incremental improvement of hand and animal-drawn implements over many decades. Field operations were not mechanized in Japan until the late 1950's.[99]

---

[95] H. F. McColly, "Agricultural Mechanization in East Asia," in Mechanization of Agriculture (Michigan State University, International Programs, 1967).

[96] Ibid.

[97] The Third Five Year Plan (1965-70), (Karachi: Government of Pakistan Press, 1967), pp. 402-403.

[98] Kang Chao, op. cit., p. 115.

[99] Hiromitsu Kaneda, "Economic Implications of the 'Green Revolution' and the Strategy of Agricultural Development in West Pakistan," The Pakistan Development Review, Vol. IX, No. 2 (Summer 1969), p. 121.

Table 17

Indicators for Agricultural Mechanization

Country	Number of Tractors[a] (Year in Parentheses)	Number of Garden Tractors[a]	Tractor Power (1965) (1000 HP)[b]	HP/100 Hectares of Area Sown to Cereals[c]
Japan	278,000 (70)	3,030,000 (68)	29,431	950
Sri Lanka	8,000 (70)	29 (69)	51	78
Taiwan	410 (70)	9,400 (65)	61	60
Philippines	5,252 (67)		163	29
China	165,000 standard (70)		1,950	16
India	54,000 (66)		1,587	15
Pakistan	7,500 (65)		50	3
N. Korea	15,900 (65)			
S. Korea	120			

Sources: a. Production Yearbook, 1971 (Rome: FAO, 1972), pp. 486, 487, 492.

b. Yujiro Hayami and Vernon Ruttan, Agricultural Development: An International Perspective (Baltimore: Johns Hopkins Press, 1971), p. 324.

c. Data on area sown to cereals from Production Yearbook, 1971.

Mechanization of agriculture will be able to proceed rapidly in China for several reasons. First, the fact that agriculture has been collectivized vastly simplifies both management of field operations--as there are no small, scattered plots--and financing of machinery.

In some countries mechanization is delayed from fear that it will encourage a bimodal pattern of development, with large farms developing to use big machinery. These large farms will have lower costs and will push prices of grain down, with disastrous effects on small farmers, resulting in further polarization.[100]

[100] Hiromitsu Kaneda, "Economic Implications of the 'Green Revolution' and the Strategy of Agricultural Development in West Pakistan," op. cit., pp. 132-33.

In China, there is to some extent such a bimodal pattern, with state farms being the large scale producers. However, because they are owned and operated directly by the state, they do not upset marketing patterns or result in concentration of political power in the hands of large landlords as has been observed elsewhere, e.g., in Pakistan.

What do changes in agricultural productivity mean in the day-to-day life of the Chinese (or other) farmer? The changes we have been discussing are not necessarily related directly to the standard of living of the peasants. Many other factors are important. The level of extraction determines the extent to which peasants can benefit from gains in agricultural productivity; in China, extraction has been quite low so that much of the benefits of increased productivity have remained with the peasants. Of course, standard of living includes much more than economic factors. Some of the most important gains for the Chinese peasants have come from a system of distribution of food which assures that food will be available regardless of floods or droughts. For Chinese peasants who previously experienced periodic famines and general uncertainty of survival, guaranteed food is extremely important. Moreover, the elimination of a wealthy, powerful, and often brutal class of landlords has increased the dignity of the average peasant. Availability of health services and education in rural China have also improved the standard of living. Another element in standard of living is personal freedom--freedom to move, to have personal relations, to have unorthodox political views or to pursue private economic activities. In these dimensions the Chinese system is deficient. A great many factors

affect the standard of living of peasantse and I do not want to attempt here to balance the positive and negative factorse But obviously, food production is a sina qua non for a decent life, and evidence shows that China's agriculture has been transformed as rapidly as, or more rapidly than, most other Asian countries into a modern agriculture that reliably produces adequate food. For the future, China faces great challenges along with all other Asian countries.