K. William Easter

For Restricted Circulation to Seminar Participants only

BACKGROUND PAPERS FOR DISCUSSION

AT

THE INTERNATIONAL SEMINAR

ON

"COMPARATIVE EXPERIENCE OF AGRICULTURAL DEVELOPMENT IN DEVELOPING COUNTRIES SINCE WORLD WAR II"

NEW DELHI

25th, 26th, 27th and 28th OCTOBER. 1971

THE INDIAN SOCIETY OF AGRICULTURAL ECONOMICS
46-48, Esplanade Mansions, Mahatma Gandhi Road, Fort,
BOMBAY-1.

ENVIRONMENTAL, TECHNOLOGICAL, AND INSTITUTIONAL FACTORS IN THE GROWTH OF RICE PRODUCTION : PHILIPPINES, THAILAND AND TAIWAN*

S.C. Hsieh and V.W. Ruttan@

Introduction

A basic premise of the technical assistance and agricultural development programs of the late 1940's and early 1950's was that rapid growth in agricultural productivity and output could be achieved by the transfer of technology, institutions, and capital from high-income to low-income countries. It was thought that agricultural production could be expanded rapidly as a result of (a) the transfer of known agricultural technology from the high-productivity to the low-productivity countries, (b) the development of more effective rural marketing, credit, and land tenure institutions, and (c) capital investment in irrigation and flood control, mechanization and transportation. The diffusion of practices employed by the best farmers within the low-income countries was also regarded as an important source of productivity growth.

Such expectations have typically failed to materialize. The rate of growth of crop output in most developing

---

* This paper draws heavily on several earlier reports by Ruttan, Soothipan, and Venegas (23, 24); Hsieh and Lee (9); and Abarientos (1).

countries have been disappointingly slow. Furthermore, a relatively large share of the recorded increases in production have been based on expansion of area planted rather than on increases in output per unit area (6).

Now, in the mid-1960's a new concensus appears to be emerging that intensive investment in research and development designed to produce improvements in the quality of agricultural inputs represents the missing link in the agricultural development process in many countries (8, 16, 25, 26). There is increasing recognition that traditional practices employed by the more successful farmers in each area do not have a sufficiently high payoff to provide an incentive for rapid growth in aggregate output. And there is growing agreement that much agricultural research and development is highly location specific--it must be done in biological and economic environments approximating those where the innovation will be employed.

There is danger that these insights may be contributing to a new set of over-simplifications regarding the requisites for rapid agricultural development. The evidence presented in this paper emphasizes the essential complementarity between (a) increased investment in research and development leading to higher rates of return on purchased inputs, (b) increased investment in land and water development, and (c) improved institutional and organizational systems for providing technical inputs and services to farmers.

Most countries in Southeast Asia have been, and continue to be, more dependent on increased area than on increased yield as a source of growth in rice production (Table 1). This is in contrast to the countries of Northeast Asia where increases in yield have been more important

Table 1. - Production, Area, and Yield of Rice in Asia, 1961/62-1963/64 Average Compared with Ten Years Earlier*

Regions and Countries	Production, rough rice (thousand matric tons)			Area (thousand hectares)			Yield (tons per hectare)			Percentage contribution to change in production	
	1951/52 to 1953/54	1961/62 to 1963/64	Per cent change	1951/52 to 1953/54	1961/62 to 1963/64	Per cent change	1951/52 to 1953/54	1961/62 to 1963/64	Per cent change	Change in area	Change in yield
Northeast Asia											
Japan	12,043	16,880	40.2	3,013	3,286	9.1	4.00	5.14	28.5	26	74
Korea(Rep. of)	2,318	3,532	52.4	946	1,147	21.2	2.45	3.08	25.7	46	54
Taiwan[a]	1,947	2,586	32.8	784	775	- 1.1	2.48	3.34	34.7	- 4	104
Total	16,308	22,998	41.0	4,743	5,208	9.8	3.44	4.42	28.5	27	73
Southeast Asia[b]											
Burma	5,836	7,392	26.7	4,112[c]	4,637[c]	12.8	1.42	1.59	12.0	51	49
Cambodia	1,679	2,474	47.3	1,673	2,305	37.8	1.00	1.07	7.0	83	17
Indonesia	10,090	12,504	24.4	6,131[d]	6,960	13.5	1.65	1.80	9.1	59	41
Malaysia	660	980	48.5	498[d]	474	-4.8	1.32	2.07	56.8	-13	113
Philippines	3,052	3,907	28.0	2,589	3,142	21.4	1.18	1.24	5.1	78	22
Thailand	7,389	9,208	26.6	5,599	6,077	8.5	1.32	1.52	15.2	37	63
Total	28,706	36,465	27.0	20,602	23,595	14.5	1.39	1.55	11.5	57	43
South Asia[e]	49,874	69,756	39.9	40,441	45,741	13.1	1.23	1.53	24.4	37	63

* Data from FAO, The World Rice Economy in Figures, 1909-1963 (Commodity Reference Series No.3, Rome, 1965); FAO Production Year Book 1965, FAO Monthly Bulletin of Agricultural Economics and Statistics, June 1966. The author has computed the relative contribution of area and yield to the change in production on a logarithmic basis.

a. Production and yield differ from figures used elsewhere in this paper, apparently due to conversion from brown to rough rice at 1.24 here rather than 1.312.

b. Laos and Vietnam not included.

c. Planted

d. Including approximation for Sarawak for comparability with production figures.

e. Ceylon, India, Iran (unofficial), and Pakistan, Nepal not included.

than increases in area in recent years. Taiwan and Malaysia are the only countries, however, which seem to have achieved their total increase in output during the last decade from yield increases. The Philippines and Cambodia stand at the opposite extreme. Thailand ocucupies an intermediate position; changes in yield are somewhat more important than changes in area planted in accounting for increases in rice production in Thailand during the last decade.

Two hypotheses with respect to the factors affecting yield increases and yield differences are tested in this study.

The first is that the increases in yield of rice of the last decade and the differences in yield among major rice-producing areas within Southeast Asia at the present time primarily reflect variations in the environmental conditions under which rice is grown (soil, season, water and weather differentials) rather than differences in variety or cultural practices.

The second hypothesis is that differences in rice yield between Southeast Asia and Northeast Asia reflect variations in the technological and institutional factors under which rice is grown in addition to environmental factors.

In this paper, we test these two hypotheses with data from the Philippines, Thailand, and Taiwan. Major emphasis will be placed on factors associated with changes or differences in yield.[1]

---

1 We do not attempt, in this paper, to analyze the factors associated with the expansion or decline of area devoted to rice. Work has recently been completed relating the response of area devoted to rice and other crops to product and factor price behavior (2, 20). In general the results indicate that the area planted to rice tends to be highly responsive to changes in produce prices relative to competing crops. These studies typically did not identify any significant response in yield to changes in relative prices.

Trends in Rice Production, Area, and Yield in Three Countries

The Philippines, Thailand, and Taiwan have all experienced relatively rapid growth in total rice production since the early 1900's. The pattern of growth over time and the relative contribution of area and yield are sharply different among the three countries (Chart 1,* Table 2)

Throughout the entire period a substantial share of total increase in output in both the Philippines and Thailand is accounted for by increases in the area devoted to rice production. Growth in area was particularly rapid in both countries prior to the early or mid-1920's. In Taiwan, however, the expansion of area planted was relatively slow throughout the entire period, although rather substantial increases were recorded during the 1920's and early 1930's.

There have also been sharp contrasts in yield. In the Philippines yield per hectare apparently rose rapidly from an extremely low level in the early years of the century to approximately 1.20 metric tons per hectare in the mid-1920's. In both Thailand and Taiwan yields were substantially higher than in the Philippines and in Taiwan remained slightly below 2.0 metric tons per hectare until the early 1920's.

Since the mid-1920's national average rice yields in the Philippines seem to have remained almost unchanged. In 1962/63-1963/64 the Philippine average yield was only 1.25 metric tons per hectare. The average yield in Thailand declined continuously from the early 1920's to the mid 1950's. During the late 1940's and early 1950's it was only slightly higher than in the Philippines. Although the long term decline in yields was reversed by the late

---

* Chart 1 not reproduced here.

Table 2. -Changes in Rice Production, Area, and Yield in the Philippines, Thailand, and Taiwan for Selected Periods (Rough Rice Basis)*

Period	Production (thousand metric tons)	Area (thousand hectares)	Yield (tons per hectare)	Annual rate of change (per cent)		
				Production	Area	Yield
		Philippines[a]				
1908/09-1909/10	798	1,174	.68	...	...	...
1925/26-1926/27	2,140	1,781	1.20	6.0	2.5	3.4
1952/53-1953/54	3,163	2,650	1.19	1.5	1.5	.0
1962/63-1963/64	3,905	3,124	1.25	2.1	1.7	.5
1908/10-1962/64	...	...	...	3.0	1.8	1.1
		Thailand				
1907/08-1908/09	2,475	1,319	1.88	...	...	...
1920/21-1921/22	4,250	2,298	1.85	4.2	4.4	.1
1946/47-1947/48	4,974	3,907	1.27	.6	2.1	1.4
1962/63-1963/64	9,711	6,288	1.54	4.3	3.0	1.2
1907/09-1962/64	...	...	...	2.5	2.9	.4
		Taiwan				
1903/04-1904/05	735	415	1.75	...	...	...
1919/20-1920/21	916	499	1.84	1.4	1.1	.3
1936/37-1937/38	1,761	670	2.63	3.9	1.7	2.1
1951/52-1952/53	2,004	787	2.55	.8	1.1	- .2
1962/63-1963/64	2,769	772	3.58	3.0	- .2	3.2
1903/05-1962/64	...	...	...	2.2	1.0	1.2
1919/21-1962/64	...	...	...	2.6	1.0	1.6

* See Appendix Note for sources of basic data. Area figures are harvested basis except as indicated for the Philippines in note a. Annual rates of change are the authors' computation.

a Area figures are area planted prior to 1953/54, area harvested thereafter. Yield figures reflect this change.

1950's, the average yield in 1962/63-1963/64 was still only 1.54 metric tons per hectare--substantially below the levels achieved before the 1920's. During this same period Taiwan experienced a spectacular growth, with yield per hectare rising from 1.84 metric tons per hectare in 1919/20-1920/21 to 3.58 in 1962/63-1963/64.

Both the long-term stability in national average yield in the Philippines and the long-term decline in national average yield in Thailand are difficult to explain. The stability in national average yield in the Philippines may reflect the combined effect of expansion in area devoted to low-yielding upland and rainfed rice and a stable or declining area devoted to rice production in the higher-yielding irrigated areas. In Thailand, it is possible that increases in area devoted to rice in the low-yielding provinces of the northeast have more than offset the effect of stable or rising yields in the central and northern provinces.

In Taiwan, the higher yields seem to have been due primarily to favorable technological and institutional factors, which include the development and introduction of high-yielding ponlai rice varieties, increased use of chemical fertilizer, improved irrigation facilities and water management, improved cultural practices, reduced acreage of low-yielding upland and rainfed rice, and the organization of farmers' associations and irrigation associations for fertilizer distribution, rice collection, storage, processing and marketing, and water use, water distribution, and water management at the local level. Among all these factors it appears that innovations associated with the introduction of the ponlai varieties beginning in the early 1920's have been particularly important. Data on the long-term yield trends for the several classes of rice grown in Taiwan is presented in Chart 2.*

---

* Chart 2 not reproduced here.

The Institutional Conditions for Growth*

The essential technological and environmental elements for rapid development of the Taiwan rice economy were available by the mid-1920's. Introduction of these elements resulted in increases in yield per hectare of over 2.0 per cent per year until 1938, when Japanese military efforts began to divert resources from development objectives. Since the early 1950's rice yields have again risen rapidly even though the technological and environmental factors were not greatly different from those in the mid-1920's and early 1930's.

In spite of continued varietal development work, it appears that the yield potentials, under optimum environmental and management conditions, have not changed significantly since the late 1920's or early 1930's. It has previously been pointed out that greater fertilizer availability has been one factor permitting closer approximation of average to potential yields. It also seems clear that the evolution of the farmers' associations into effective extension and marketing organizations and the improvement in incentives resulting from the land reform of 1949-52, have played a significant role in the achievement of higher rice yields.

Farmers' associations.-- Approximately twenty years elapsed between introduction of the first Japanese rice varieties and the development of the ponlai varieties to the point where they were suitable for rapid diffusion. It took roughly twice as long to develop

---

* Sections on "Differences in Yield among Regions in the Philippines, Thailand, and Taiwan," "Regional Yield Comparisons between the Philippines, Thailand, and Taiwan," "Technological and Institutional Factors in Taiwan," and "The Technological Conditions for Growth," (pp. 313-334) have been dropped.

fully effective institutional arrangements for rapid diffusion of new technology, the dissemination of credit, and marketing of agricultural supplies. The efforts to develop institutions to perform these functions have focused on the farmers' associations (9).

The first farmers' association was established in Taipei Prefecture in 1900. By 1908 sixteen had been organized to provide a direct link with experiment stations in introducing seeds of new varieties and in dissemination of improved farm practices. The associations also purchased and distributed fertilizer. They came under formal government regulation in 1908, and membership and collection of dues became compulsory. The system was reorganized in 1927. Agricultural improvement stations were established in each prefecture with direct linkage to the prefectural associations. By the early 1930's the associations employed 1,148 agricultural technicians. Their responsibilities had expanded to include extension of new agricultural practices, handling of land rent disputes between landlords and tenants, seed multiplication, fertilizer distribution, and related activities. The associations were again reorganized in 1937 in order to strengthen them in the townships and villages.

While the system of farmers' associations was evolving, cooperatives were being fostered to provide credit to small business and to farms. By the early 1930's the cooperatives had added purchasing, marketing, and warehousing services. Considerable duplication had developed between the activities of the associations and the cooperatives and in 1943 they were combined into a single organization.

After the establishment of Chinese administration, the farmers' associations and the cooperatives were

first separated in 1946 and then reunified in 1949. Under the new reorganization steps were taken to decentralize the administration of the associations and to give greater authority to the farmer members.

The period since 1950 has been one of continued development. The credit functions and the handling of farm supplies and marketing of farm products of the old cooperative system were fully integrated with the extension and technical advisory services of the farmers' associations.

A combination of market power and efficient administration combined to make the association an efficient agent of technological change. Both market and non-market devices were coordinated to induce the cultivator to adopt the highest-yielding varieties, apply high levels of fertilizer, and adopt labor-intensive production practices directed at achieving rapid increases in yield.

The farmers' association system has evolved from a prewar pattern based very heavily on administrative control from the center down to the individual farmer to a system which relies primarily on a combination of technical information and market incentives in the factor and product markets to induce production decisions on the part of individual farmers.

Land tenure.-- A second factor in the rapid growth of yield per hectare during the last decade and a half has been the incentive for more intensive use of purchased inputs, family labor, and land associated with the land reform of 1949-53. The first stage of the program involved a compulsory reduction in rent. The second

stage involved purchase and resale of rented land to the tenant. Tenancy declined from 39 per cent to 17 per cent of farm families between 1949 and 1957. The land reform did not involve the breaking up of large estates but rather the transfer of tenant units from ownership of landlords to ownership of cultivators (28).

The implications of the land reform for incentives to use purchased inputs and household labor is consistent with the empirical evidence. The rapid increase in fertilizer use on rice reviewed earlier was clearly a joint result of the availability of the fertilizer, a favorable rice-fertilizer barter ratio in relation to the high-potential response of rice output to fertilizer,[11] and the additional incentive associated with an owner-operator system as compared with a share tenure system. Dramatic increases in the multiple cropping index and in labor input per worker were probably even more closely associated with the increased incentives for more intensive use of family labor.[12]

- - - - - - - - - - - - -

11 The fertilizer-rice barter ratio in Taiwan has been criticized as relatively unfavorable in comparison with some other developing countries. However, given the relatively steep slope of the physical output response relationship for the ponlai varieties under irrigated conditions it has been profitable for Taiwan farmers to use relatively high levels of fertilizer on rice.

12 The changes in farm employment, labor input, and double cropping can be summarized as follows (1911-15=100):*

	Number of agricultural workers	Labor input in man days/worker	Multiple cropping index
1911-15	100	100	116
1921-25	98	118	121
1946-50	144	141	151
1956-60	149	198	180

* Data from S.C. Hsieh and T.H. Lee (9, pp. 24, 41).

The Taiwan experience is consistent with the proposition that institutional development has to be built up through a process of selection, trial and error, and adaptive research similar to the manner in which new varieties are evolved. Both the agricultural technology and the institutions must be developed, or at least tested and modified, in the location in which they are to be utilized (19).

Considerations in the Design of a Strategy for increasing Rice Production in Southeast Asia

The analysis of the previous sections can be summarized as follows :

1. Prior to the mid-1920's differences in rice yields among the three countries--Philippines, Thailand, and Taiwan--and among regions within each country were due primarily to differences in the environmental conditions under which rice was grown rather than to technological, economic, and social differences. The dominant environmental factor was irrigation and the precision of water treatment control.

2. With the introduction of the nonlai varieties by the Japanese in Taiwan in the mid-1920's technology became a dominant variable in explaining the rapid increase in rice yields in Taiwan and in explaining differences in rice yields between Taiwan and the other two countries. An important factor in the rapid diffusion of the new varieties and the use of higher levels of technical inputs such as fertilizer was the rapid irrigation development in Taiwan which began shortly after 1900 and continued through the 1920's. Achievement of the yield potentials inherent in the new varieties was stimulated by institutional developments, such as (a) the organization of

farmers' associations and irrigation associations during the period of Japanese occupation and (b) the successful implementation of the land reform program and the reorganization of the farmers' associations into effective integrated farm supply, credit, and marketing cooperatives following the restoration of Chinese administration after World War II.

3. In the Philippines and Thailand differences in yield both between the two countries and among regions within each country are still primarily due to differences in environmental conditions under which rice is grown. When differences in season (wet or dry) and water treatment (irrigated, rainfed, or upland) are taken into consideration very little difference in yield is left to be explained by such factors as new varieties, differences in cultural practice, more intensive use of technical inputs, or differences in economic and social institutions.

4. Both the Philippines and Thailand may now be approaching a yield take-off similar to that experienced in Taiwan in the mid-1920's. Yields in the major producing regions in both countries have been rising at about the same rate during the last decade as in Taiwan during the decade following introduction of the ponlai varieties. Furthermore, new higher-yielding varieties having a yield potential of at least 6.0 metric tons during the wet season and 8.0 metric tons during the dry season when grown under irrigation with an appropriate complement of technical inputs are now being introduced (11).

Yet despite the yield potential inherent in the new varieties now being introduced there seem clearly to be basic deficiencies in the sequence of development

programming which may prevent the Philippines and Thailand from repeating the experience of Taiwan. In Taiwan a major share of the basic investment in irrigation was already completed before the beginning of the biological revolution that lead to the yield take-off in the 1920's. Furthermore, the irrigation development leading to effective water control was a prerequisite to the effective diffusion of the new higher-yielding, labor-intensive, "fertilizer consuming" rice varieties. Institutional innovations such as extension work, farmers' associations, irrigation associations, and land reform followed and complemented both the investment in water control and the technological changes.[13]

In the Philippines and Thailand a reverse pattern is being followed. Efforts to develop agriculture following World War II have concentrated very heavily on institutional development. In the Philippines this effort is currently being supplemented by substantial efforts to develop and introduce high-yielding rice varieties responsive to fertilizer similar to the ponlai varieties introduced in Taiwan in the mid-1920's.

Neither the Philippines nor Thailand yet place major emphasis on the development of irrigation systems designed to provide a dependable water supply in both the wet and dry seasons to a major portion of the area devoted to rice production. It seems apparent that this lag of land and water resource development behind the institutional and technological changes will impose serious limitation on achievement of the output potential associated with the technological advances that are now being realized.

---

13 The Taiwan experience is also consistent with the Japanese experience where effective water control also has represented a significant factor in the diffusion of rice production technology (15).

A high percentage of the lowland rice in the Philippines and Thailand is grown during the rainy season without irrigation. Under this rainfed system of cultivation, village or provincial average yields rarely exceed 1.5 metric tons per hectare. In fully irrigated areas in both countries, however, in areas such as Cheingmai (Thailand) or Laguna (Philippines) average yields often exceed 3.0 metric tons in the wet season and 3.5 metric tons in the dry season, over fairly substantial areas. On such individual farms as participate in contests, or under experimental conditions, yields of the same varieties under irrigated conditions frequently fall in the range of 4.0-4.5 metric tons in the wet season and 5.0-6.0 metric tons in the dry season (3,10).

A major implication of this analysis is that the factors which permit a province or region to increase its yield from 1.5 metric tons per hectare in the wet season to the levels currently being achieved in the higher yielding areas of each country are primarily beyond the control of the individual farmer in the major rice-producing areas such as central Luzon or central Thailand. Modifications in the environment necessary to achieve effective water control through irrigation and drainage during both the wet and the dry seasons will have to come primarily from public or semi-public agencies capable of organizing resources in a manner that is almost invariably beyond the capacity of individual tenants or farm owners.

A second major implication is that the limitations on environmental control that prevent farmers from achieving the yield potentials of existing varieties will be an equally severe limitation on achievement of the much higher yield potentials embodied in the new varieties now

being introduced. These new varieties are even more sensitive than existing varieties to effective environmental control, technical inputs, and management.

The ecology of the monsoon tropics and the factor and product price relationships which characterize current development levels rule out the direct transfers of existing rice production technology from temperate region countries such as Japan and the United States. Even transfer within Southeast Asia, from Taiwan to the Philippines or Thailand, have not been successful.

But it is possible to transfer the propensity and the capacity to focus scientific manpower and other resources on technical problems of economic significance and the skill that comes from having solved similar problems although in a different environment. This involves skill (a) in breeding for fertilizer response, disease resistance, grain quality, and other elements, and (b) in using the local ecological information supplied by soil chemists, physiologists, entomologists, cereal chemists, geneticists, agronomists, economists, and others to select and achieve appropriate breeding objectives and breeding strategy.

The magnitude of the investment required to realize the production potential inherent in the new technology that is being created tends to be substantially underestimated. There will have to be massive investment in the industries that produce the inputs of fertilizer and insecticides; there will have to be massive investment in irrigation if the investment devoted to development of new varieties and production of the technical inputs is to achieve a reasonably high return; and it will be necessary to commit substantial increases in trained

manpower to the tasks of management related to the direct investment and to educational work associated with rapid achievement of the production potentials.

Recognition of the complementarity between these infrastructure investments and the investments in research and development to create new production potentials raises a serious question about the validity of the assumption that primary emphasis on research and development could provide a relatively inexpensive route to rapid growth of agricultural production during the early stages of agricultural development.[14] These assumptions typically rest very heavily on analogies with the Japanese experience since the Meiji Restoration in 1868 and on the Taiwan experience after 1900 (14a). In both Japan and Taiwan, however, a relatively high percentage of the rice producing areas had already been brought under cultivation before the beginning of the "biological revolution" associated with the heavy use of natural and commercial fertilizer, introduction of higher-yielding fertilizer, responsive rice varieties, intensive use of insecticides and other agricultural chemicals.

This failure to develop an effective water storage, transportation, and drainage system for rice production in the monsoon areas of Southeast Asia at an earlier

---

14 B.F. Johnston and G.S. Tolley (13) indicate that "initial emphasis should be placed on innovations that do not require large increases in the use of purchased inputs. This means emphasis upon the development and introduction of innovatinns such as high-yielding varieties, improved crop rotation, optimum spacing and time of planting, and a better seasonal distribution of the work load" (13, p. 369). This advice does not appear relevant in the tropical rice producing regions of South and Southeast Asia. Without massive investment in irrigation these innovations will not result in higher productivity.

stage in development was due to a major extent to the differences in physical geography. Both Japan and Taiwan are characterised by short river valleys and narrow coastal plains which lent themselves to locally organised, small-scale, labor-intensive irrigation and drainage works. Water typically did not have to be transported over long distances. In contrast to Japan and Taiwan the major rice producing areas of Southeast Asia are characterized by broad river valley and plains. Under these conditions, the physical geography dictates the organization of large national systems. The construction of such systems lends to much more capital-intensive patterns of investment in water storage, transportation, and drainage in contrast to the relatively labor-intensive system employed during the early stage of development in Japan and even Taiwan.

Clearly, the investment requirements for growth of the agricultural input sectors and for infrastructure development in the rice-producing countries of South and Southeast Asia will be very high over the next several decades.[15] Furthermore, these investments will be competitive with other development goals. Unfortunately, investment in research and development has not opened up a new low-cost route to the rapid growth of agricultural output in those areas. It can provide one of the essential elements in a total program to achieve increases in agricultural production.

- - - - - - - - - - - - - -

15 For a discussion of irrigation costs in the Philippines and other Southeast Asian countries, see Levine (18) and President's Science Advisory Committee (29).

Citations

1 E.P. Abarientos, "An Analysis of Rice Production in Taiwan" (International Rice Research Institute, Los Banos, August 1966), mimeo.

2 J.R. Behrman, "Price Elasticity of the Marketed Surplus of a Subsistence Crop," Journal of Farm Economics, November 1966.

3 R.F. Chandler, "Maximum Yield Potentialities for Rice," The Philippine Agriculturalist, September, 1962.

6 W.E. Hendrix et al., Changes in Agriculture in Twenty-Six Developing Nations, 1948 to 1963 (U.S. Agricultural Economics Report No. 27, Washington, D.C., November 1965).

8 F.F. Hill, "Some Viewpoints Concerning Agricultural Development." Paper presented before the American Farm Economic Association, Allied Social Science Association meeting, New York, December 28, 1965.

9 S.C. Hsieh and T.H. Lee, Agricultural Development and Its Contribution to Economic Growth in Taiwan--Input-Output and Productivity Analysis (Joint Commission on Rural Reconstruction, Economic Digest Series No. 17, Taipei, April 1966).

10 International Rice Research Institute, Annual Report, 1964 (Los Banos, 1965).

11 ----------, IRRI Reporter, September 1966.

13 B.F. Johnston and G.S. Tolley, "Strategy for Agricultural Development," Journal of Farm Economics, May 1965.

14a B.F. Johnston, "Agriculture and Economic Development: The Relevance of the Japanese Experience," Food Research Institute Studies, Vol. 6, No. 3, 1966.

15 Natsuki Kanazawa, "Difference Between Rice Cultural Management Under River and Pond Irrigation." Paper presented at the Pacific Science Congress, August 1966.

16 C.E. Kellogg, "Interactions and Agricultural Research in Emerging Nations," in A.H. Moseman, ed., Agricultural Sciences for the Developing Nations (American Association for the Advancement of Science, Washington, D.C., 1964).

18 Gilbert Levine, "Irrigation Costs in the Philippines," The Philippine Economic Journal, First Semester 1966.

19 E.J. Long, "Altering the Variables of the Food Supply-Demand Situation." Paper presented at the Conference on Alternatives for Balancing Future Food Production Needs, Center for Agricultural and Economic Development, Iowa State University, Ames, November 1966.

20 Mahar Mangahas, A.E. Recto, and V.W. Ruttan, "Market Relationships for Rice and Corn in the Philippines," The Philippine Economic Journal, First Semester 1966. See also Journal of Farm Economics, August 1966.

23 V.W. Ruttan, A. Soothipan, and E.C. Venegas, "Changes in Rice Production, Area, and Yield in the Philippines and Thailand," World Crops, March 1966.

24 ----------, "Technological and Environmental Factors in the Growth of Rice Production in the Philippines and Thailand," Rural Economic Problems, May 1966.

25 T.W. Schultz, Transforming Traditional Agriculture (New Haven, 1964).

26 ----------, "Economic Growth from Traditional Agriculture," in A.H. Moseman, ed., Agricultural Sciences for the Developing Nations (American Association for the Advancement of Science, Washington, D.C., 1964).

28 H.S. Tang and S.C. Hsieh, "Land Reform and Agricultural Development in Taiwan," The Malayan Economic Review, April 1961.

29 U.S. President's Science Advisory Committee, The World Food Problem, Vol. II (Report of the Panel on the World Food Supply, Washington, D.C., May 1967).