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AN ECONOMIC ANALYSIS OF GOVERNMENT ACTIVITIES IN THE  
DEVELOPMENT OF THE PHILIPPINE RICE INDUSTRY

by

*Kelly*  
Mahar Mangahas, 1944-

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The University of the Philippines  
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Mahar Mangahas

1. Research Problem

A general problem on which little research has been done concerns the efficiency of alternative sequences and combinations of government programs that seek to transform traditional agriculture.<sup>1</sup> It is becoming more apparent that the expected rate of return from one government program depends significantly on other programs, and it is thus becoming more important to be able to provide a quantitative description of this dependence.

The key program, according to the new consensus, is agricultural research leading to the development of new plant varieties and animal breeds. There has been impressive economic growth associated with such research in the United States, Japan, Mexico and Taiwan, to mention only the cases familiar to me. The rate of growth varies with the rate of diffusion of the new varieties and the yields that farmers attain per unit area or per animal, which components depend in turn on a number of factors which existing government programs are able to affect.

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\*Outline of Ph.D. dissertation research for the University of Chicago, Department of Economics.

<sup>1</sup>C.R. Wharton, Jr., "Infrastructure for Economic Growth," in H.M. Southworth & B. F. Johnston (eds.), Agricultural Development and Economic Growth, Cornell University Press, 1967, esp. 116-8.

The recent development and initial diffusion of new, fertilizer-responsive and highly productive rice varieties in the Philippines<sup>2</sup> provide an opportunity for a useful investigation of the relative economic merits of complementary government activities. I propose to use cross-sectional data from the first few growing seasons (1966 or 1967 up to approximately June, 1969) to study the effects of a number of variables, most of which are related to government activities, on the diffusion rate of and the yields attained with the new varieties. To obtain indicators of the variables likely of importance in the case of the Philippines, I examine below (a) the technical nature of the new rice varieties, (b) the rice "success story" of Taiwan, and (c) a case study of a new agricultural management firm out to exploit the new varieties.

## 2. The New Rice Varieties

Under experimental conditions, the new varieties give yields three times as large as traditional irrigated yields, and hence promise a major transformation of the rice industry. The experimental yields are obtained under several important conditions:

1. irrigation, and especially in the dry season;
2. high levels of fertilization;
3. high levels of chemical plant protection;
4. improved methods of labor application.

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<sup>2</sup>This development is due mainly to the large increase in the scale of rice research in the Philippines following the establishment of the International Rice Research Institute (IRRI) at Los Baños, Southern Tagalog region, in 1960.

The efficiency of fertilization and of application of protective chemicals depend partly on irrigation. Control of the level of standing water in a lowland farm among other things will make it less likely that rains will wash away applied fertilizer, will permit the use of systemic insecticide, and will decrease the population of weeds.

Traditional Philippine varieties are generally tall, leafy, profuse tillering, photoperiod-sensitive, and susceptible to lodging. They are able to produce moderate but stable yields under adverse conditions as deep water and intense weed competition, and are adapted to conditions of low fertility and minimum care. Photoperiod-sensitive varieties have been naturally selected where water control is slight, since they may be planted whenever monsoon rains begin, yet will always mature at a fixed date after the monsoon season; harvesting is easier and the chance of typhoon damage at late stages of growth is minimized. Yield increases through a high rate of application of nitrogen or dense planting are not large due to lodging susceptibility. Lodging also raises the cost of harvesting and lowers the quality of the grain. The new varieties being developed are short and stiff-strawed, with short, narrow, erect and dark green leaves, are medium tillering and of early maturity, and are capable of substantial grain response to nitrogen without lodging.<sup>3</sup>

The new Los Baños varieties (IR8 and IR5) are recommended for irrigated lowland farms. So far as I can gather, rainfed lowland farms are recommended to use somewhat older varieties developed by government

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<sup>3</sup>University of the Philippines (College of Agriculture) and International Rice Research Institute, Rice Production Manual, 1967.

research stations (e.g., BPI-76), which are lower-yielding but hardier plants.

There are five meaningful environmental classes of riceland:

1. Wet season rainfed lowland
2. Wet season irrigated lowland
3. Dry season rainfed lowland
4. Dry season irrigated lowland
5. Wet season rainfed upland

"Lowlands" are level and have dikes and diversion ditches, etc. for impounding of water. The term "upland" has no slope or elevation connotation; this type of land by definition has no facilities for impounding water. The cost of transforming upland area into lowland area does depend on the slope of the land, since the cost of terracing increases with slope.

The quality of irrigation in the dry season apparently depends on whether water storage facilities exist. The shortage of such facilities appears to be the main reason why average wet season yields have been higher than average dry season yields. Given an adequate water supply, however, the yield potential is greater in the dry season because the weather is sunny and free from typhoons. Higher dry season yields are indeed the experience in experiment stations.

The total area cultivated in the dry season has always been less than that in the wet season. Some land used for rice in the wet season is not used thus in the dry season, partly because the lack of sufficient water causes yields to be low, partly because of the alternative of plant-



ing other dry season crops which make more efficient use of the limited water supply.

### 3. The Philippines and Taiwan Compared

In the view of Hsieh and Ruttan,<sup>4</sup> the consensus that varietal research is the key development program has emerged not only because of its associated success but also because of the disappointing performance of other programs pursued in East Asia in the later 1940's and 1950's. These programs concentrated on the diffusion of the practices employed by the best local farmers, transfer of known agricultural technology from high productivity countries, development of rural marketing, credit and land tenure institutions, and investment in irrigation, flood control, mechanization and transportation. With Taiwan as the reference, they warn however against rejection of all these programs in favor of a new set of oversimplifications regarding varietal research.

They find the Philippine experience, until recently, to be comparable to the Taiwan experience until the mid-1920's, in that rice yield differences across the countries and across regions within countries are primarily explainable by environmental conditions: the proportions of crop area irrigated in the wet and dry seasons. In the mid-1920's the Japanese introduced ponlai rice Varieties in Taiwan, and thenceforth the new varieties became the primary factor explaining the growing difference between Taiwan and Philippine rice yields.

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<sup>4</sup>S.C. Hsieh and V. W. Ruttan, "Technological, Institutional, and Environmental Factors in the Growth of Rice Production: Philippines, Thailand and Taiwan," Food Research Institute Studies, forthcoming.

Their report on complementary government programs is worth quoting:

"In Taiwan a major share of the basic infrastructure investment in irrigation development was already highly developed before the beginning of the biological revolution that led to the yield take-off in the 1920's. Furthermore, the irrigation development leading to effective water control represented a prerequisite to the effective diffusion of the new higher yielding, labor intensive, 'fertilizer consuming' rice varieties. Institutional innovations such as the organization of extension work, farmers' associations, irrigation associations, and land reform followed and complemented both the infrastructure investment and the technological changes.

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

"Neither the Philippines nor Thailand are yet placing major emphasis on the development of irrigation systems designed to provide a dependable wet and dry season water supply to a major portion of the area devoted to rice production. It seems apparent that this lag in 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."<sup>5</sup>

These remarks imply the following testable hypothesis: in the Philippines, cross-sectional differences in the levels of acceptance of and the yields attained with the new rice varieties will be primarily explained by the cross-sectional distribution of capital in the forms of irrigation and land improvements.

### 3. Entrance of the Agricultural Management Firm

The first new variety (IR8) released by IRRI was available to farmers at least as early as the dry season (roughly the first half) of 1966. Its promise was such that a number of firms were rapidly organized which offered to manage rice farms for landlords and tenants in

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<sup>5</sup> Hsieh and Ruttan, op.cit., pp. 56-7 of mimeographed copy.

return for a proportion of the difference between the IR8 yield and an agreed-upon previous normal yield under old varieties, net of added operating costs. I would interpret successful establishment of these firms as one indicator of the importance of the quality of the farm operator as a variable determining modernization.

The criteria one firm uses in selecting clients<sup>6</sup> are of note because they may indicate other important determining variables (remarks are in parentheses):

1. The firm does not accept a farm that has already been regularly obtaining a yield of 80 cavans (3.52 metric tons) per hectare. (For such a farm the absolute profitability of a varietal change is quite low.)
2. The farm must be accessible by road, and preferably located close to warehousing and processing facilities. (Isolation from the market may be an important determining variable, especially in a country with a spotty transportation system.)
3. The farm must be adequately irrigated even during the dry season.
4. The firm manages only contiguous farm area of at least 50 hectares. Smaller contiguous farms are acceptable as joint clients. (In general, larger farm area implies more efficient use of the short supply of skilled farm management. If skilled operators are being drawn to large estates by decisions of landlords, it is conceivable

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<sup>6</sup>J.D. Drilon, Jr., "Toward Self-Sufficiency in Rice," The Philippine Review of Business and Economics, 4:2 (November 1967), 42-62. This is a report on case studies done of two Philippine agricultural management firms.



that modernization will turn out to be positively related to the rate of tenancy. This will imply that the landlords are probably non-absentee and technology-conscious.)

5. The firm deals with owner-operated farms, and with tenant-operated farms only if landlord and tenants "have a fairly good relationship." (This is consistent with the hypothesis that modernization is negatively related to the rate of tenancy unless landlords in fact make the major production decisions for the farming units they own.)

#### 4. Factors Determining Modernization

The average rice yield of a given district is determined by (a) the level of acceptance of the new varieties and (b) the average yields attained with new and with old varieties. The economist's explanation for cross-sectional variation in these variables is that there probably is a cross-sectional variation in profitability variables.<sup>7</sup> It is contended that these are the principal explanatory variables even for agriculture in a poor country.<sup>8</sup> The research I propose will test the applicability of these statements in the case of rice in the Philippines.

I plan to consider the following factors:

1. The environmental distribution. This is the distribution of crop area into the five classes of land described in Section 2. Of course only four of the five proportions in the distribution are in-

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<sup>7</sup>Cf. Z. Griliches, "Hybrid Corn: An Exploration in the Economics of Technological Change," Econometrica, 25 (1957): 501-22; E. Mansiield, "Technical Change and the Rate of Imitation," Econometrica, 29 (1961): 741-66.

<sup>8</sup>T. W. Schultz, Transforming Traditional Agriculture, Yale University Press, 1964, Ch. 11, and the references therein.

dependent. The five proportions can be determined from the following four meaningful variables:

- a. The ratio of crop area in lowland farms.
- b. The irrigated hectarage ratio for lowland farms in the wet season.
- c. The irrigated hectarage ratio for lowland farms in the dry season.
- d. The dry season / wet season irrigated hectarage ratio.

All the coefficients on these variables are expected to be positive, given the technical considerations outlined in Section 2. According to the analysis of Hsieh and Ruttan, the coefficients are expected to be highly significant.

2. The relative advantage of new varieties over old, as given by:

- a. The absolute difference between the average yield with old varieties and the normal yield farmers expect to attain with the new. For the latter variable I shall examine new variety yields taken both from previous experience by farmers and from nearby demonstration plots and experiment stations. The latter localities are prime sources of information for farmers especially when varieties are being newly introduced, i.e., they are initial links in a chain of information that is still quite short.
- b. The relative variance of new over old variety yields, also as indicated by the sources mentioned above. Observed

values of this variance ratio are expected to be larger than one, since it is reported that the old varieties are able to produce moderate but stable yields under rather adverse conditions.<sup>9</sup>

The coefficients of these two variables are expected to be positive and negative respectively. The relative advantage of new varieties, as indicated by both variables, is expected to decrease as the distance from Los Baños increases. The greater the rate of decrease of relative advantage, and the larger the coefficients are absolutely, the stronger is the case for increased budgetary support of government experiment stations for the local adaptation of the Los Baños varieties.

The experience in Taiwan would lay stress on the importance of continued adaptive research. Hsieh and Ruttan report that in 1922, the first ponlai variety yielded 3.78 m. tons on its first commercial trial. But although the Taiwan national average rice yield began to rise more swiftly from then on, it did not reach 3.5 m. tons until the 1960's. The long delay was partly due to the high susceptibility of the ponlais to rice blast disease until 1929, when more resistant varieties were introduced.<sup>10</sup>

3. The quality of the farm operator. The potential importance of this variable has been indicated by the readiness of farm management firms to enter the market following the introduction of the new varieties. Indicators of quality to be considered are :

- a. Age
- b. Schooling

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<sup>9</sup>Rice Production Manual, pp. 17, 55.

<sup>10</sup>Hsieh and Ruttan, op.cit., p. 4<sup>th</sup> of mimeographed copy. The delay was also partly due to the deterioration of irrigation facilities and the shortage of fertilizer during and immediately following the war.

c. Urbanization or isolation, as measured by distance to (urban) centers of agricultural knowledge.

d. Yields attained with old varieties in periods previous to the introduction of the new varieties, relative to average yields over all farmers in the same periods (this variable is less justifiable when fertilizer-responsive varieties are present).

e. Measures of the extent of farming information made available to farmers by extension services (both public and private), e.g., extension workers, per farmer, in the last X years.

4. The availability of complementary inputs. Variables to be considered would be factor prices (but there may be little cross-sectional variation here) and distances from outlets of the major input suppliers.

a. Fertilizer. The total supply of fertilizer may not be a serious limiting factor, because of the recent large expansion in capacity of manufacturers.<sup>11</sup> The adequacy of the fertilizer distribution system will however require serious study.

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<sup>11</sup>The nutrient required is mainly nitrogen. A rough calculation of total national nitrogen consumption by rice farmers, using 1964/65 hectareage levels and assuming 100% acceptance of recommended varieties and recommended nitrogen application levels, is 162,000 m. tons. (Incidentally, the recommended nitrogen levels are those which maximize yields at the Los Baños area; profit maximization levels would be lower.) On the other hand, total nitrogen production capacity of the four main fertilizer companies is by rough calculation at least 95,000 m. tons.; two of the companies have started constructing additional ammonium sulfate capacity. Of course other crops share in this fertilizer output; but it should be noted that the new rice varieties have been available for only about two years. See Esso Standard Fertilizer and Agricultural Co. (ESFAC), Fertilizer: Its Importance in the Development of Philippine Agriculture, December 1966; UN, Economic Commission for Asia and the Far East, Mineral Raw Material Resources for the Fertilizer Industry in Asia and the Far East (Mineral Resources Development Series No. 28), New York, 1967, pp. 14-5.

b. Other inputs. There are some promising new implements available, e.g., the garden tractor, the rotary weeder, which may or may not have measurable effects as yet on the modernization process. The particular traditional input of which more is required by new varieties is harvest labor. This variable too may or may not have a measurable impact.

5. Market institutions. The public programs of the 1950's emphasizing government credit and the formation of farmers' cooperatives, suggest that policymakers felt that poor organization of the agricultural inputs market was a development bottleneck. The recent agricultural research, stressing the low fertilizer responsiveness of traditional varieties and the much higher yield ceilings obtainable from new varieties, suggests on the other hand that the development potential of these government-sponsored institutions may be greater now, with the introduction of the new varieties, than a decade ago. I plan to consider these institutions by taking measures of their scale of operations and farmer membership.<sup>12</sup>

6. The rate of tenancy. Unless landlords participate in production decisions, the effect of a proportional sharing system

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<sup>12</sup>In the case of the rural banks, which were supposed to have been organized for small farmers, but which make loans primarily to landowners (rather than tenants) and impose a very high security value to loan ratio (from 3 to 5), some of the effects may be "picked up" by the rate of tenancy and farm size variables. See L. P. de Guzman, "An Economic Analysis of Agricultural Loans Granted by Rural Banks in Luzon," Philippine Agriculturist, 39:611-9 (March 1956).



between landlord and tenant is the application of non-land inputs at levels below the equality of the marginal product and marginal factor cost. Yields of the new rice varieties would be seriously affected if such a decision were made by tenants with respect especially to fertilizer.

This is an important variable from the viewpoint of current policy, because land reform officials have set up a costly program to prevent new owner-operators from slipping back into tenancy. The method used (in 1965 at least) was to supply each land reform area with a government team offering farmers intensive extension, credit and legal services. Declaration of high-tenancy areas as land reform areas has proceeded slowly due to the shortage of trained government manpower, as well as the requirement that priority be given to irrigated areas. Such a costly and slow-moving program may be justified if the returns from a permanent shift from tenancy to owner-operatorship are shown to be relatively high.

##### 5. On Projection of Program Benefits

My main objective is to identify the government programs of great complementarity with the new technology, by studying the cross-sectional relation between, on one hand, the acceptance level and yields of old and new varieties, and on the other the several variables itemized in Section 4. The ultimate purpose of providing such information is to help estimate the rates of return of alternative sets of government programs, i.e., to help project the expected stream of benefits deriving from a given set. A second objective of the research

is to attempt such a projection, necessarily rough in view of the shortness of time series data.

For this projection, I plan to assume, first, that future output growth shall stem only from yield increases, total hectarage remaining constant, and, second, that product and factor prices will remain at the average of a few recent periods. The research will probably be confined to Central Luzon, the oldest producing region, for which expansion of agricultural hectarage is no longer possible except for multiple cropping should the dry season water supply be increased. The trend of rice hectarage in the 1960's in this region has been declining somewhat, due to shifts from rice to sugarcane (the Philippines is favored by the U. S. quota system). The projection of program benefits under the assumption of constant hectarage is not necessarily invalid when there actually are hectarage shifts, since the change in benefits as calculated from the viewpoint of demanders and suppliers meeting in the rice market is partly compensated by an opposite change in benefits in the markets of the crops to or from which hectarage shifts.

The average yield in any period is given by the level of acceptance of (or proportion of hectarage planted to) the new varieties and by the current yields of new and old varieties. Apart from weather effects, changes in the yields of new and old varieties through time will occur as farmers acquire more knowledge and (up to a point) increase application of fertilizer and similar inputs. Such increases in input application rates are conceivable, given no changes in product and factor prices, if for some reasons -- at least the cost of learning and unlearn-

ing--the optimal application rates under conditions of full knowledge (defined say as knowledge existing on experiment stations) cannot immediately be obtained. In order to project future yields, I shall try to determine the most important factors that have determined yield differences through time, focusing on those which are influenced by the government programs already enumerated.

// Both time-series and cross-sectional data are available for old varieties. I do not expect to find that much of the yield differences are accounted for by differences in per hectare levels of purchased inputs. Differences in the environmental distribution,<sup>13</sup> in the quality of farmers and (minor) improvements through time in the quality of the varieties may turn out to be the important factors.<sup>14</sup> //

Projection of new variety yields and levels of acceptance are necessarily still tenuous. The history of the diffusion of the new varieties is just beginning. A crude method would be to use per period changes in yields and acceptance levels, for the few seasons that have been observed, as dependent variables in the regressions on the explanatory factors of Section 4. Then for a given set of values of the explan-

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<sup>13</sup>Cf. E. C. Venegas and V. W. Ruttan, "An Analysis of Rice Production in the Philippines, "Economic Research Journal (University of the East), 11:3 (December 1964), 159-80.

<sup>14</sup>In the time series analysis of yields of old varieties, I will try to obtain data for an additional variable, on research results of nearby experiment stations. If the assumption that research establishments are subject to strong increasing economies of scale is correct, then the coefficient of this variable should turn out to be small, since the scale of operations of government experiment stations is relatively small, especially in comparison with the International Rice Research Institute.

atory factors (assumed to hold during the forecast period), the computed per period yield changes and acceptance level changes can be used to project future yields and acceptance levels up to certain arbitrary maxima.

The method implies that the expansion paths for yields and acceptance levels of the new varieties are linear (up to the periods when the maxima are reached). While this may not be too unrealistic in the case of yields,<sup>15</sup> it is certainly contrary to the S-shaped acceptance level time paths that have invariably been found in previous research.<sup>16</sup> Thus, the projection of the acceptance level time path will probably require revision when (and if) the S-shape becomes more distinct.

Once projected benefit-streams are available, alternative sets of government programs can be compared following a procedure previously used to estimate the returns to agricultural research.<sup>17</sup> This procedure being rather familiar, I will summarize the parameter requirements.

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<sup>15</sup>Cf. Fig. 3.0 (Long Term Changes in Rice Production, Area and Yield: Taiwan, 1900-1963) of Hsieh and Ruttan, *op.cit.*, p. 10 of mimeographed copy. The average yield trend in Taiwan during the "take-off" is about linear.

<sup>16</sup>Cf. Griliches and Mansfield, works cited. There is also an extensive rural sociological literature on the S-shaped acceptance level path; for references see E. M. Rogers, Diffusion of Innovations, New York: Free Press, 1964.

<sup>17</sup>Cf. Z. Griliches, "Research Costs and Social Returns: Hybrid Corn and Related Innovations," JPE, 66 (1958): 419-31.

First of all, the elasticity of demand is required; for this parameter I propose to simply take several "reasonable" estimates, one at a time. Next one needs to assume either that the supply function is vertical or that it is horizontal. In the former case, the parameter required is the relative change in output corresponding to a given change in the set of programs. The amount of benefits so obtained is adjusted for additional factor costs under the set of programs which delivers the higher output level. In the latter case, the parameter required is the relative change in average cost of production. This change is determined by the relative change in yield and the relative change in total cost per hectare corresponding to a given change in the set of programs.

Another procedure<sup>18</sup> would allow for, but also require an estimate of, a finite non-zero elasticity of supply. Estimation of the yield response of new varieties to price would definitely require much longer time series data than will be available, considering that cross-sectional price variation is minimal. Hence I do not foresee being able to use this procedure.

## 6. Sources of Data

### 1. Yields, inputs and rates of acceptance

a. The Department of Agriculture and Natural Resources (DANR) conducts an annual crop and livestock survey. I will try to obtain disaggregated data from the 1967, 1968 and 1969 surveys, which would cover the (July-June) 1966/67, 1967/68 and 1968/69 crop years.

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<sup>18</sup> Cf. W. Peterson, Returns to Poultry Research in the United States, Ph.D. thesis, University of Chicago, 1966, pp. 55-7.



b. The International Rice Research Institute conducted several short surveys for the 1967 wet season in the Central Luzon and Southern Tagalog regions and has information on comparisons between traditional and improved varieties with respect to yields, cost and returns. A 10% sample survey of all barricos in 4 provinces of Central Luzon is currently underway (it is currently the 1968 dry season).<sup>19</sup> Data for one province are already available.

c. Fertilizer companies. There are a handful of these, of which the largest is apparently Esso Standard Fertilizer (ESFAC). ESFAC markets its product through part-time "agroservice" dealers of whom most have had technical training in agriculture and many are farmers themselves. It may be possible for me to obtain some cross-sectional data on fertilizer consumption from these dealers (numbering probably more than 400 by now).

d. Local governments. At least one provincial government (Rizal) has established and is collecting data from its own rice "crash program."

## 2. Environmental distributions

a. The 1960 census of agriculture provides a base set of data, disaggregated to the municipality level, from which I plan to make estimates of the distributions of different types of land for current years, given information from other sources (below) as to irrigation projects and expansion of total hectarage since 1960.)

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<sup>19</sup>Communication from Randolph Barker, IRRI agricultural economist, 13 March 1968.

b. The DANR periodically makes surveys to determine the environmental distribution. The surveys to my knowledge since 1960 were in 1960/61, 1963/64, 1964/65 and 1965/66.

c. The National Irrigation Administration is responsible for gravity irrigation projects, while the Irrigation Service Unit (ISU) is responsible for pump irrigation projects. The pump projects of ISU are owned by private cooperatives, which repay ISU over a long period. The activities of these two agencies probably account for most of the additions to irrigated rice land each year.

### 3. Local research and extension

Sources of data would be records of the DANR's Bureau of Plant Industry, Bureau of Agricultural Extension, Bureau of Agricultural Economics, and the Commission on Agricultural Productivity. The Philippine Rural Reconstruction Movement is a private institution which also engages in some extension work. ESFAC has sponsored a large number of demonstration plots comparing old with new varieties.

### 4. Government market institutions

This institutions of interest are: (a) the Farmer's Cooperative Marketing Associations (FACOMAS), formerly supervised by the recently abolished Agricultural Credit and Cooperatives Financing Administration (ACCFA), and probably supervised now by the Agricultural Credit Administration, successor to ACCFA; and (b) the Rural Banks, supervised by the Central Bank of the Philippines. Sources of data would be the supervising institutions and the Agricultural Credit and Cooperatives Institute (affiliated with the University of the Philippines).

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5. Land tenure

The 1960 census is a base set of data. Absolute distributions of farm area according to form of land tenure are available by municipality. I plan to make adjustments according to information on the operations of the National Land Reform Council, and its assisting institutions, the Land Authority, the Land Bank, and the Commission on Agricultural Productivity.

6. Farmer schooling

The 1960 census gives schooling data for the entire population of a district. These will be taken as estimates of farmer schooling, urban districts being eliminated. In areas dominated by rice culture, e.g., Central Luzon, errors should not be substantial.

As indicated above, most of the important material shall come from government reports and records and unpublished survey data. I shall concentrate on regions in which much diffusion of the new rice varieties has taken place, i.e., the Central Plain of Luzon and the nearby coastal and lake areas of the Southern Tagalog region. The Central Plain is the major rice producing area of the country. It consists of about three or four thousand square miles of almost unbroken flat land, and is probably quite homogeneous with respect to land resources. (Soil maps are available to check on this point.) The Southern Tagalog area referred to is relatively small. However, this is where major rice research and field testing take place.