IRRIGATION AND AGRICULTURAL DEVELOPMENT: MICRO- AND MACRO-LEVEL EXPERIENCES IN THE PHILIPPINES**

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ABSTRACT

Given the virtual disappearance of a land frontier due to rapid population increase, growth momentum in agriculture must be shifted from area expansion to land productivity increase. Land productivity can be increased by intensifying land use and/or by increasing yield per unit of crop area. Irrigation is the most strategic factor in enhancing land productivity, because it can contribute in both ways. This paper aims at confirming this fact by examining Philippines' experiences. A review of agricultural history of two rice villages reveals that the impact of multiple cropping under irrigation on the agricultural development at a village level is considerably higher than under rainfed conditions. The macro-level experience in the Philippines indicates that the government basically has dealt well in exploiting the irrigation potential of increasing land productivity by investing in irrigation infrastructure. However, the short run over-responsiveness in irrigation investment might have had an adverse impact upon government investment decision on the long run need of irrigation. The need to develop irrigation infrastructure both for enhancing production to meet the increasing food demand and for providing employment opportunities to the growing rural labor force will continue to be imperative in the near future.

Introduction

Countries of South and Southeast Asia have experienced rapid growth in agricultural production in the last decade. The major factors behind the growth have been irrigation development and diffusion of seed-fertilizer technology, of which the former factor has been more critical, in a sense that the yield increase potential of seed-fertilizer technology can only be realized on well-developed irrigation infrastructure (KIKUCHI and HAYAMI, 1978b). Given the high rates of population growth in these countries, irrigation development will continue to be important in the near future. In this paper, we show the effects and needs of irrigation development for agricultural development based on micro- and macro-level experiences in the Philippines.

Micro-level experience: Effects of irrigation at the village level

Let us identify first the effects of irrigation upon agricultural development at a village level. Two villages in two major Philippine rice-growing provinces were selected for comparison; one in Laguna and the other in Iloilo. Henceforth the former will be called Laguna Village and the latter Iloilo Village. Major changes in the situation of agriculture in the two villages since their settlement and related statistics are summarized in Tables 1 and 2, respectively.

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** The basic ideas developed in this paper are derived from the reports by KIKUCHI and HAYAMI (1978a) and KIKUCHI *et al.* (1983). Major revisions in data and estimation were made.

Table 1 Major technological and institutional changes in agriculture in two Philippine villages since their settlement

Period	Laguna Village	Iloilo Village
19th century	Settlement began (1880s) with extensive rainfed rice farming	Settlement began (1850s) with extensive rainfed rice farming
1920-40		Number of sharecroppers in rice farming increased
Late 1940s	Land frontier closed	Lowland land frontier closed Upland cultivation (corn, etc.) began
1950s		Government Mindanao resettlement project
1958	Irrigation system constructed (complete rice double cropping)	
Early 1960s	Hand tractor Improved cultural practices (fertilizer, chemical, local improved rice varieties, rotary weeder, dry seedbed) *Gama* system	Local improved rice varieties Land use intensification (multiple cropping of upland crops on lowland) Improved cultural practices (fertilizer, chemical, hand weeding)
Mid-1960s		Upland land frontier closed
Late 1960s	MVs, with further improvement in cultural practices Land reform (from share to lease) *Gama* system diffused rapidly	
1973	Credit program (Masagana 99)	Land reform (from share to lease) Masagana 99
Late 1970s	Herbicide Mechanical thresher	MV, direct seedling, partial double cropping of rice Mechanical thresher

Table 2 Selected statistics for two Philippine villages, 1920, 1950, and 1980[a]

	Laguna village			Iloilo Village		
	1920	1950	1980	1920	1950	1980
Population	51	204	706	125	349	627
Household: Farmer	9	37	46	25	52	96
Landless farm worker	-	7	71	-	...	11
Others[b]	-	-	9	-	...	12
Total	9	44	126	25	52	119
Farmland (ha)[c]: Irrigated lowland	-	-	85	-	-	-
Rainfed lowland	36*	89*	-	88*	113*	113
Upland	-	-	-	...	...	28
Total	36	89	85	88	113	141
(per farm)	4.0	2.4	1.8	3.5	2.2	1.5
(per capita)	0.7	2.4	0.1	0.7	0.3	0.2
% of farmland under tenant system	...	98	98	...	...	90
Multiple cropping ratio	1.0	1.0*	2.0	1.0	1.0*	1.9
Total village labor use for crop production (1000 workdays/year)	...	9[d]	25[e]	...	9[f]	16[g]
% of hired labor in labor use for rice production	...	58[d]	81	...	65[f]	38
Rice yield (t/ha/crop)	...	2.2	4.0	...	...	2.9
Land productivity (t/ha/year)[h]	...	2.2	8.0	...	...	4.3
Household income (t/year)[h]: Farmer	...	...	11.9	...	...	5.3
Landless	...	...	5.0	...	...	1.6
Average	...	...	7.6	...	...	5.1
Gini-ratio: Size distribution of farm land[i]	...	0.46[j]	0.77	...	...	0.31
Size distribution of household income	...	...	0.42	...	...	0.31

a Figures with asterisk are rough estimates. An ellipsis (...) indicates data not available and a dash (-) indicates none.
b Retired and non-farm households.
c Area cultivated by village farmers.
d As of 1956.
e As of 1976.
f As of 1953.
g As of 1978.
h Value terms converted into paddy rice equivalent using farm gate paddy price.
i Size distribution of operational holdings.
j As of 1960.

1 Agricultural history of the two rice villages

Both villages were settled in the latter half of the 19th century. Settlement was an unorganized process in which people moved in gradually as rice fields opened. Iloilo Village which was established a little earlier had a higher population than Laguna Village in 1920. However, the two villages had a similar land-man ratio, which indicates that they had comparable initial conditions for agricultural development. Village settlement based on the opening of new rice fields ended in both cases in the late 1940s as the land frontier virtually closed. Since then, agricultural development in the villages has been appreciably different.

2 Laguna Village

Rainfed rice farming dramatically changed when a national irrigation system reached the village area in 1958. Irrigation made double cropping of rice possible, thereby doubling the rice crop area per cultivated area and promoting the establishment of a complete rice monoculture pattern.

Irrigation also prompted other technological changes in rice farming. As rice double cropping was implemented, the use of a hand tractor and the dry seedbed method were adopted to shorten the time required for land preparation and crop establishment. More importantly, irrigation paved the way for the introduction of seed-fertilizer technology. Fertilizer and chemical application began in the early 1960s. Weeding became a common practice in line with fertilizer application. Finally in the late 1960s, the modern semi-dwarf varieties (MVs) were introduced, immediately after their development, with further intensification of crop care. By 1974, the cultivation of MVs accounted for nearly 100% (HAYAMI *et al.*, 1978).

Land reform was implemented in the village along with the MV diffusion, and share-tenants became lease-holders. Because of the rent regulation under the land reform program and the large incrase in rice yield due to the diffusion of MV technology, farmers' income increased substantially. Another institutional change to be mentioned is the change in the labor hiring arrangement for rice harvesting. The traditional system in which anyone could participate in harvesting for a share of output was replaced by a new system in which harvesting was limited to the workers who weeded the fields without receiving wages. The dissemination of this new system, called *gama,* had been rapid since the onset of irrigation (KIKUCHI and HAYAMI, 1980).

3 Iloilo Village

After the lowland land frontier closed in the late 1940s, rice farming in this village remained rainfed. The changes in the agricultural practices in this village were nevertheless as important as those in Laguna Village but more complex than in the latter.

As the lowland frontier closed, farmers gradually started to cultivate the hilly upland that had been used for grazing water buffaloes, with maize as the major crop. Upland crops began to be grown in the lowland areas when less photosensitive local improved rice varieties were introduced around 1960. The typical cropping pattern was maize-rice-mungbean. In addition to crops normally grown in the upland areas, other crops such as taro and squash started to be planted, causing the limited upland frontier in the village to be exhausted by the mid-1960s.

MVs were introduced with Masagana 99 (M-99), a government rice production-credit program. However, their performance in rainfed fields was not better than that of the existing local improved varieties. Farmers started to partially adopt MVs in well-watered lowland areas after 1975 when very early-maturing varieties (IR30, IR36), which made double cropping of rice possible, were introduced. In the late 1970s, about one-third of the village lowland was double-cropped for rice. Adoption of direct seeding and mechanical threshing reduced conflicts in timing caused by the addition of a second rice crop to the prevailing multiple cropping system.

Like in Laguna Village, the land reform was implemented together with the M-99 program in 1973. Inasmuch as the land reform reduced the rent level, farmers benefited of the situation, to a lower extent however, since the concurrent yield increase associated with the diffusion of MVs was less pronounced in this village. M-99 credit was also a one time injection of cash that was used mainly to convert existing local debts into bank debts. Similar changes in the harvesting system to those in Laguna Village occurred, to a lower extent too (HUIJSMAN, 1986).

4 Irrigated agriculture vs diversification under rainfed conditions

Both villages intensified the land use: Laguna Village through irrigation development and Iloilo Village through multiple cropping without irrigation. As a result, both villages attained a similar level of land utilization in 1980. The land utilization index for Laguna Village in 1980 was 200, and that for Iloilo Village 190.

However, the performance of agriculture in the two villages was apparently different (Table 2). It is reasonable to consider that the land productivity in the two villages used to be at about the same level until the 1950s. In 1980, the land productivity in Laguna Village was almost twice as high as in Iloilo Village due to the increase in yield per cropped area associated with irrigation. The average household income in Laguna Village was about 50% higher than that in Iloilo Village in 1980.

The difference in agricultural performance between the two villages may be better analyzed by the changes in the village population (Fig. 1). The village population can be affected by many factors such as birth and death rates, but the basic factor that determines its trend is the labor-absorbing capacity of agriculture which is, in turn, determined by the type of technologies adopted in agriculture. It is the social rate of population changes (migration rates) of a village that would reflect the labor-absorbing capacity of agriculture.

In both villages, the net migration rates fluctuated considerably over time. But, as an average of the post-world war II period, the rate for Laguna Village shows a positive value (0.2% per annum), whereas that for Iloilo Village a negative one (1-1.0% per annum). It seems reasonable to assume that the labor-absorbing capacity of irrigated (double cropping) rice farming is much higher than that of multiple cropping under a rainfed condition.

To test the hypothesis, regression analyses were performed (Table 3). To some extent, the effects of non-agricultural variables are controlled by the introduction of variables, such as nonfarm employment opportunities and war time dummies, into equations. Generally, the regression equations account well for the large fluctuations in the migration rates.

Most importantly, the irrigation development and diffusion of irrigation-based seed-fertilizer technology in Laguna Village had a very significant impact on the absorption of

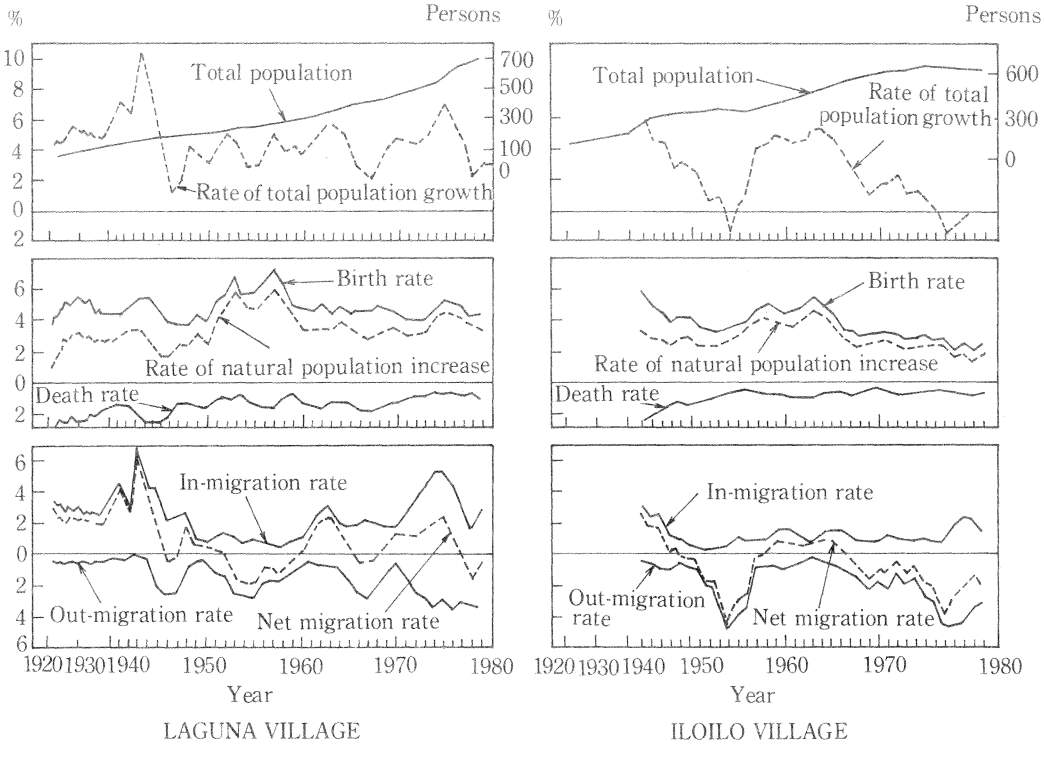

Fig. 1 Changes in population growth rates in two Philippine villages, 1920-1980.

Table 3 Regression analyses with migration rates (%) as dependent variables

Variables	Laguna Village			Iloilo Village
	In	Out	Net	Net
MAN-LAND	-1.11 (0.20)	0.25 (0.17)	-1.62 (0.29)	-1.96 (0.66)
IRRIGATION	2.11 (0.48)	-1.38 (0.40)	3.45 0.62)	
MV-LANDREFORM	7.84 (1.84)	-1.51 (1.06)	10.38 (2.32)	
GAMA	2.47 (1.68)		0.04 (2.20)	
NONFARM	-2.90 (1.31)	3.26 (1.05)	-3.92 (2.01)	-0.82 (0.95)
WAR DUMMY 1	2.14 (0.39)		2.74 (0.50)	
WAR DUMMYY 2		1.96 (0.41)	-1.50 (0.60)	
SETTLEMENT PROJECT DUMMY				-2.64 (0.40)
LV DUMMY				1.61 (0.46)
Intercept	5.39	-0.82	5.88	5,96
R^2	0.80	0.73	0.81	0.81
D-W d-stat.	2.17	0.80	1.68	1.61
F-stat.	31.3	25.9	28.2	32.6
D. F.	48	49	47	31

Regression coefficients are reported with standard errors in parentheses.

Variable definitions: MAN-LAND = man-land ratio (persons/ha); IRRIGATION = the ratio of irrigated land area to the total farmland; MV-LANDREFORM = product of MV (ratio of area planted with MV to the total planted area) and LANDREFORM (ratio of farmland under leasehold tenancy to the total farmland); GAMA = ratio of farmers adopting the *gama* system to the total farmers; NONFARM = NNP at the 1972 prices, sum of the industry and service sectors (index, 1972 = 1.0); WAR DUMMY 1 = 1 for 1941-45; WAR DUMMY 2 = 1 for 1945-47; SETTLEMENT PROJECT DUMMY = 1 for 1951-56 during which the government recruited applicants for the settlement projects in Mindanao; LV DUMMY = 1 for the years after 1960 when local improved varieties were introduced.

population from outside the village. The increase in farmers' income associated with MV technology and land reform, and the change in the harvesting system promoted the absorption of landless workers from outside. In the case of Iloilo Village, in contrast, some of the population was forced to leave as the population pressure against land increased. The government resettlement project in Mindanao in the 1950s worked as a device for drawing people from the village. Although the intensification of agriculture through multiple cropping, as represented by the dummy variable of the local improved rice varieties, had a significant impact on reversing the trend, its degree was much lower than that of irrigation development and MV *cum* land reform effect in Laguna Village.

Macro-level experience: Government investment in irrigation

Irrigation infrastucture has strong characteristics of public goods, which means that the public sector, especially the government, should take the major responsibility for its development. In this chapter, we observe the government investment in irrigation in the post-war period.

1 Shift in growth momentum in Philippine agriculture

First, the shift in the growth momentum of Philippine agriculture is illustrated in Table 4.

Table 4 Changes in the growth momentum from area expansion to land productivity growth in the Philippine agriculture

	Growth rates[a]			Relative contribution to output growth[b]		
Period	Output	Cultivated land	Land productivity	Output	Cultivated land	Land productivity
1950-1960	5.0	3.3	1.7	100	66	34
1960-1970	3.2	1.4	1.8	100	44	56
1970-1980	6.3	-0.6	7.0	100	-11	111

a % per annum.
b %.

Source: DAVID *et al.* (1984).

Both in the 1950s and in the 1970s, the agricultural output for the nation as a whole increased at an average annual growth rate of about 5-6%. However, the major momentum that brought about the growth was entirely different between the two periods; in the 1950s, more than 60% of the output growth was brought about by the increase in the cultivated land area, whereas, in the 1970s, solely by the increase in land productivity.

The basic factor at the origin of this shift was the virtual disappearance of a land frontier resulting from the population explosion in the post-war period. With increasing population pressure against land, the growth momentum had to be shifted to land productivity increase, which was reflected in the situation of the two villages as outlined previously. As in those villages, the multiple cropping index for the nation began to rise in the late 1960s when the increase of cultivated land ended while that of labor continued to be high (Fig. 2). The experience of Laguna Village suggests that irrigation development may have played a critical role at the national level too in increasing land productivity through the intensification of land use as well as the increase of yield per cropped area (KIKUCHI and HAYAMI, 1978b).

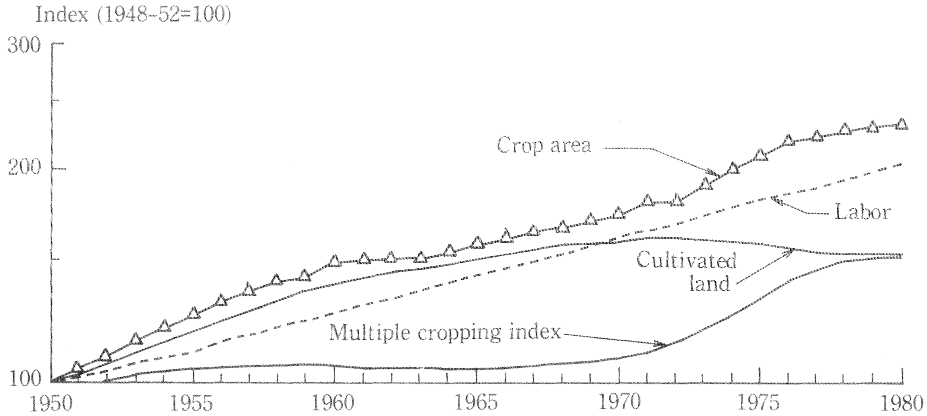

Fig. 2 Trends in land and labor in the Philippine agriculture (5-year moving averages).

Source: DAVID *et al.* (1984).

2 Determinants of irrigation investment

There are two major types of irrigation systems in the Philippines, communal and national systems. The former systems are maintained and operated communally by beneficiaries and the latter by the National Irrigation Administration (NIA). The NIA systems are of overwhelming importance in terms of command area (KIKUCHI and HAYAMI, 1978a), so that our attention in this section is limited to them.

Annual fluctuations in government irrigation investment have been extensive (Fig. 3). The fluctuations may seem totally erratic. However, a careful observation reveals that the initiation of the construction of new irrigation facilities tended to be concentrated in the years when the world rice price was rising (Fig. 4). A positive correlation is observed between government irrigation investment and world rice price, while the domestic rice price was not significantly correlated with the investment. Another fact illustrated in Fig. 3 is the trend in the acceleration in irrigation investment over time.

Based on these facts, the following two hypotheses can be formulated: 1) The trend of accelerated government investment in irrigation since the late 1950s was induced by an increasing scarcity of land due to population increase, or by the increasing difficulty to expand the cultivated land area, which increased the profitability of irrigation construction relative to land opening; and 2) The short run fluctuations in the government irrigation investment resulted from the changes in the profitability of irrigation construction, which, in turn, was largely affected by the fluctuations in the world rice price.

An overriding motive of the government policy has been to supply a sufficient amount of rice, a basic wage goods, to urban consumers at relatively low and stable prices. An increase in rice prices has an immediate impact on low income classes, often resulting in social unrest. Moreover, high rice prices adversely affect capital formation and economic growth. In order to attain this policy target, the government must have been sensitive to the increasing land scarcity and the world rice prices.

The price of rice is not the sole determinant of the profitability of irrigation investment. The rice-growing technology is also an important determinant. For assessing the profitability of irrigation investment, we estimated the B/C ratios for the construction of NIA systems by evaluating gains in rice yields by current Thai export prices, while incorporating the effects of

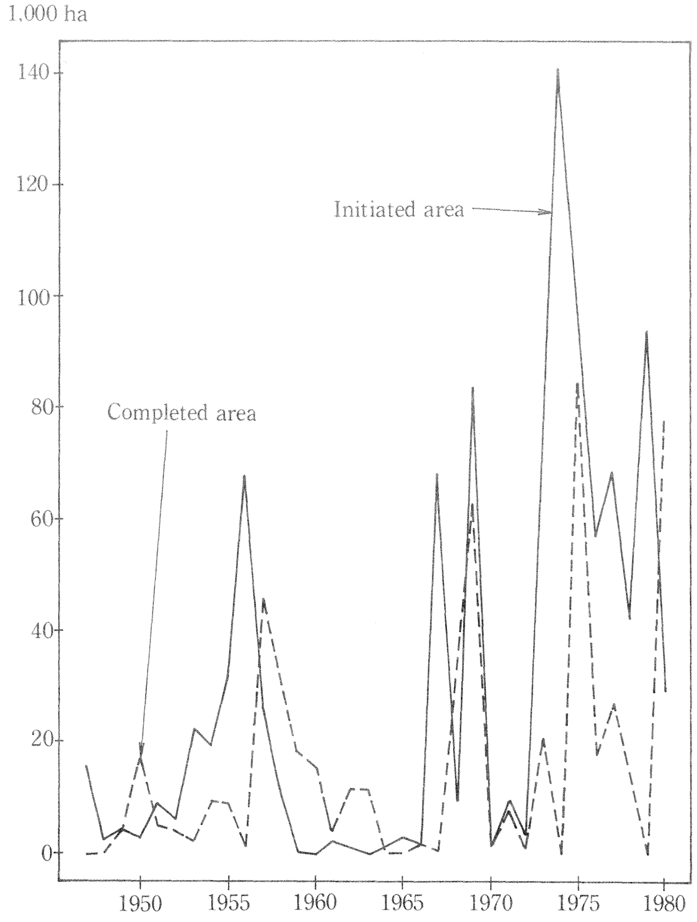

Fig. 3 Areas for which the construction of NIA irrigation systems was initiated and completed.

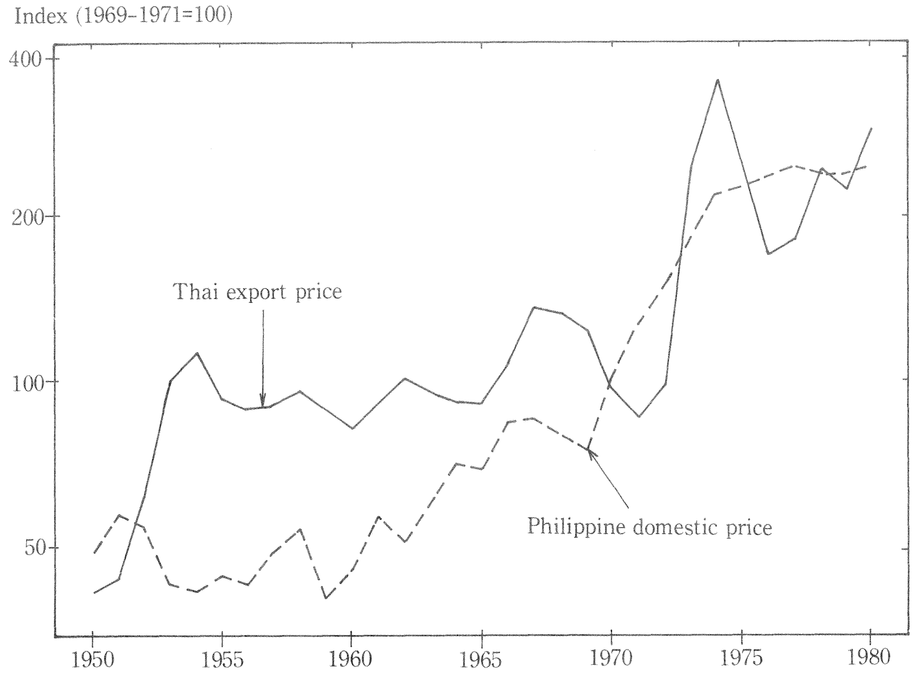

Fig. 4 Trends in the Thai export price and the Philippine domestic price of rice.

improvements in rice varieties and fertilizer applications. Such estimates are compared with increment in the area commanded by newly constructed NIA systems (Fig. 5).

The solid line replots the areas for which the new NIA construction was initiated after reducing *ad hoc* variations by taking 3 year moving averages. The dotted line plots the 3 year moving averages of the B/C ratios that evaluate benefits and costs for the projects completed in the given years. There is a close association between movements in the designed irrigable area and the B/C ratio. Such association strongly supports the second hypothesis mentioned above. However, despite the positive correlation between the NIA construction areas and the B/C ratios, they move in opposite directions as secular trends; while an increase in the designed irrigable area tends to accelerate over time, the B/C ratio tends to decline. Therefore, the trend acceleration in government irrigation investment can not be explained by changes in current profitability. The explanation should be sought in the long run increase in the profitability of irrigation investment relative to land opening.

As an econometric test of our hypotheses, regression analyses were performed (Table 5). A linear regression model was estimated for the whole period and for two sub-periods before and after the food crisis in the early 1970s. In regressions 3, 5 and 7, the B/C ratios evaluated by the Philippine domestic rice prices are used. As expected, in these regressions, $(B/C)^D$ is not significant for all cases.

In regression 1 with the B/C ratios evaluated by Thai export prices, both $(B/C)^W$ and S are statistically significant at a conventional level, which strongly supports our two hypotheses. It is interesting to note that S is not significant in the sub-period 1 while significant in the sub-period 2, and that $(B/C)^W$ and S have a larger coefficient in the second sub-period. This result

Table 5 Regression analyses of NIA irrigation investments

Variables	Whole period (1951-1979)			Sub-period 1 (1951-1970)		Sub-period 2 (1971-1979)	
	1	2	3	4	5	6	7
$(B/C)^W$	9.98 (5.25)	9.39 (3.61)		12.0 (2.99)		45.1 (7.23)	
$(B/C)^D$			5.57 (4.89)		3.52 (3.35)		-37.1 (40.8)
Land scarcity index (S_t)	137 (36.5)	71.6 (30.7)	104 (31.1)	32.1 (22.0)	12.8 (29.8)	643 (128)	-18.6 (372)
Lagged dependent variable (Z_{t-1})		0.740 (0.116)					
Intercept	-263	-158	-185	-81.7	-15.3	-1381	208
R^2	0.356	0.767	0.303	0.482	0.061	0.878	0.341
D-W d stat.	0.34	1.35	0.54	0.57	0.59	2.42	0.63

Regression coefficients are reported with standard errors in parentheses. Regression equations are: $Z_t = a + b(B/C)_t + c(S_t)$ and $Z_t = a + b(B/C)_t + c(S_t) + d(Z_{t-1})$.

Variable definitions: Z_t = the area for which the construction of NIA irrigation systems was initiated in year t; $(B/C)^W$ = benefit-cost ratio of the NIA irrigation construction evaluated by using Thai export price of rice; $(B/C)^D$ = benefit-cost ratio of the NIA irrigation construction evaluated by using Philippine domestic price of rice; S = the index of scarcity of land for cultivation calculated by $S_t = A_t/(M-A_t)$, where A_t is actual cultivated area in year to and M is the maximum area that can potentially be brought into cultivation.

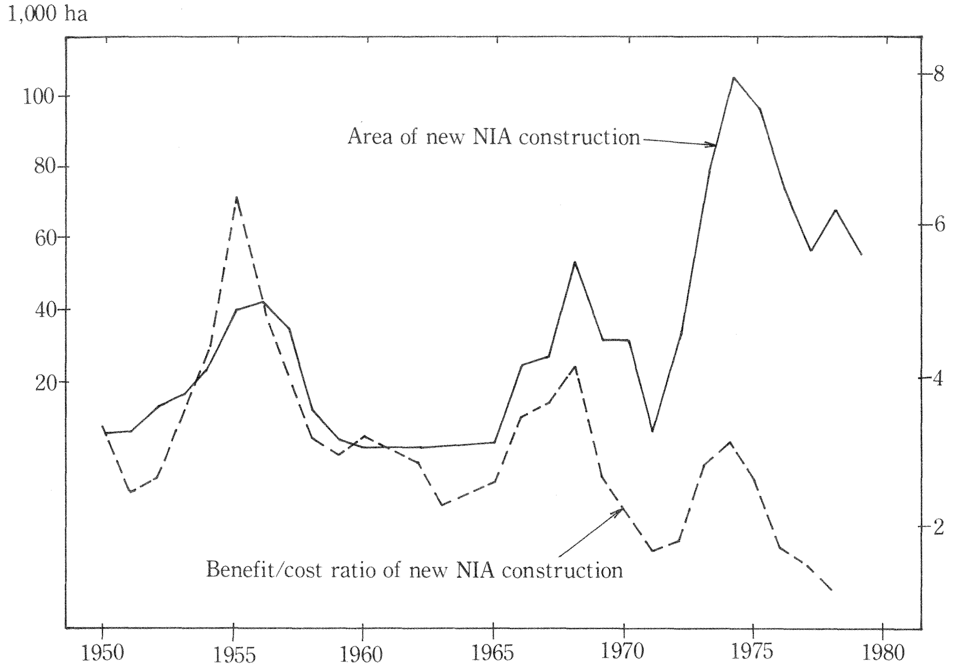

Fig. 5 The areas of new NIA construction and benefit/cost ratios of the construction, three year moving averages.

may suggest that the government realized better the long run need to invest in irrigation after the last food crisis.

Concluding remarks

Irrigation is a strong means of increasing land productivity, both through the expansion of effective areas for cultivation and the increase of yields per cropped area. Especially, its impact on the increase of agriculture's labor-absorbing capacity, and hence supporting income in rural areas, is incomparable. Inasmuch as the role of agriculture in providing employment opportunities to the growing labor force continues to be important, irrigation development may be the most effective way to fulfill the role.

The government basically deals well with the need for developing irrigation infrastructure. However, the very large short run fluctuations in government irrigation investment shown in Fig. 3 suggest that the government has been overly responsive to the short run fluctuations in rice prices so that its investment decision on the long run need of irrigation infrastructure has often been disturbed. In the Philippines, the rate of population growth is still high, and in some rural areas such as Laguna Village studied in this paper the natural rate of population growth is as high as 3.5%, as shown in Fig. 1. The need of irrigation development, both for meeting the increasing food demand and for providing employment opportunities to the growing rural labor force will continue to be imperative in the near future.

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