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TRENDS AND DETERMINANTS OF IRRIGATION INVESTMENT IN THAILAND

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EXECUTIVE SUMMARY

Unlike the rice importing countries in Southeast Asia, Thailand generally did not use irrigation policy to accelerate rice production for domestic consumption. Rather, rice policy and irrigation development in Thailand has been motivated by the use of rice exports to generate government revenue and foreign exchange. Accordingly, Thailand's early irrigation development and investment was concentrated in expansion of cropped area. As incentives and objectives shifted over time, both area and yield increases contributed to acceleration in Thai rice production.

Until the mid-1970s, expansion of cropped area was the major source of rice output growth in Thailand. As the per hectare costs of irrigation development increased and returns fell, yield growth per hectare came to play a relatively more important role. Irrigated area continued to increase and have grown from 0.59 million hectares in 1950 to 3.91 million hectares in 1987. Annual growth rates of irrigated area have declined from a high of 7.8 percent during the first development plan (1962-66) to 3.0 percent per year during the fifth development plan (1982-86).

Correspondingly, yields per irrigated hectare increased in the 1970s and 1980s, while unirrigated rice yields remained stagnant. In addition to expanding the rice planted area, irrigation inducement to shift planting technology from broad-casting to transplanting and its complementarities—high-yielding varieties, chemical inputs, and fertilizer—have also contributed to the increased rice yields on irrigated area.

The purpose of early water resource development projects was to provide supplementary water for rice cropping in the wet season, resulting in an expansion of rice cropped area above that under rainfed conditions. These large-scale systems included construction of a number of multi-purpose projects which, apart form irrigation benefits, also served other purposes as flood control, hydroelectric power generation, saline water protection, navigation and fishery. The irrigation policy emphasis on large projects continued throughout the first and second national development plans (1961-66 and 1967-71).

In the mid-1960s, the possibility of controlling water for the dry season became evident after the completion of the Bhumiphol Dam. This, together with the development in agricultural technology that resulted in rice varieties suitable for the dry season, led to a revision of irrigation policy objectives beginning with the third development plan period. The objectives shifted from delivery of supplementary water to cropped area in the wet season to water delivery for cropping throughout the year.

In addition, benefits from the large projects completed during the first two plan periods turned out to be smaller than expected, due to a lack of water delivery systems at the farm level. Consequently, a shift in investment priorities across types of irrigation works occurred. Greater emphasis was placed on small projects such as ditches and dikes, drainage canals and laterals

in the existing large facilities, as well as small tanks and weirs throughout the water-shortage areas in the Northeast and North regions. Accordingly, there has been a significant drop in the real growth rates of irrigation budgets for large and medium projects since the third plan period. As a result, areas in newly constructed large projects have not been as efficiently transformed into cropped areas as in earlier years.

The shift in irrigation policy from an emphasis on large projects to small and medium-size projects has benefitted some areas which were classified as irrigated but did not receive adequate water for cultivation. The construction of water distribution and drainage systems at farm level brought additional rice land into cultivation, especially in the dry season. The proportion of irrigated area planted with rice in the dry season almost doubled between early 1970s and mid-1980s. Still, for the country as a whole only about 20 percent of total irrigated area was under rice production in the dry season.

However, the impetus for increasing dry season area planted with rice has diminished as the benefits of such projects fell short of expectations. An inadequate supply of water from upstream reservoirs, resulting from insufficient wet season rainfall and the competing needs of hydroelectric power generation, was a principal constraint to increasing dry season irrigated area. Benefits from yield-enhancing projects, on the other hand, have been much more significant. With the shift in production technology and complementarity of high-yield varieties, fertilizers, and pesticides; wet and dry season yields in irrigated areas continued to increase beginning in the late 1970s. Correspondingly, irrigated area growth slowed as yields per hectare on additional acreage remained stagnant and constraints on cultivable land became more apparent.

Shifting incentives have also brought about a change in the regional pattern of irrigation investment. Since the 1950s, resources were concentrated in the important rice producing Central Plains region. Over the years, particularly during the fourth plan period (1977-81), greater emphasis was placed on the North, South, and Northeast regions. The distribution remains skewed, however, as most of the large projects like the Greater Chao Phya and the Greater Mae Klong Projects are located in the Central Plains region.

By the time of the sixth development plan (1987-91), most of the projects with low per hectare investment cost and high economic returns had been constructed. Responding to reduced incentives, the Royal Irrigation Department has changed its development priorities in the sixth plan to emphasize rehabilitation and maintenance of existing projects including improved water delivery, distribution, and drainage, so that water can be made available in the amount and time required for the use of new agricultural technology.

Other development directions include diversions of water from the Mae Klong to the Chao Phya river basin, a longer-term project to solve future water-shortage problems in the area. In addition, there are plans for the further development of groundwater for agriculture; long-term investment planning for systematic development of entire river basins, with greater

considerations for the conditions of natural resources in the area; water resource projects for consumption purposes; and hydroelectric generation.

Thai irrigation has thus evolved from a primary mission of building large, extensive projects for the benefit of low-input, wet season rice to a concern with improved water management and distribution of existing systems to facilitate intensified cropping of rice and other crops, and to construction of smaller-scale systems that are more adaptable to diversified cropping. As shown in the econometric analysis, these policy changes have occurred in response to direct economic incentives, including the declining world price of rice and the increasing costs of irrigation development, and in response to the rapid and diversified growth in Thai agriculture.

1. INTRODUCTION

Rice policy in Thailand has historically been driven by the desire of the government to generate revenues and foreign exchange through exports of rice. Domestic price policy was largely determined by export policies such as export taxes and quotas. However, beginning in the mid-1970s, there was a broadening of policy concerns of the government in the rice sector, with an increased concern for domestic consumer and farmer welfare, and for domestic price stability.

Unlike the rice importing countries in Southeast Asia, Thailand has generally not used production policy programs to accelerate production and influence domestic prices. With relatively abundant land for expansion of cropped area, there has been less reliance on intensification of rice production than in countries such as Indonesia and the Philippines. However, as will be shown below, there has been a shift since the mid 1970s, with yield growth playing a larger role in overall production growth as expansion of cropped area slowed. An important contributor to this yield growth has been the expansion in irrigated area.

This paper assesses trends and determinants of irrigation investment in Thailand. The paper examines trends in rice area, yield, and production in irrigated and non-irrigated areas; assesses trends in irrigation investment and service area completion; examines the status of irrigated area and yield on a regional basis; presents results from the estimation of irrigation investment functions which explain changes in government irrigation investment levels over time; and summarizes policy directions in irrigation.

2. TRENDS IN NATIONAL RICE AREA AND YIELD

Official data on crop production in Thailand, including rice area, yield, and production by wet and dry season, are collected by the Office of Agricultural Economics of the Ministry of Agriculture and Cooperatives (MAC). The Royal Irrigation Department (RID) further subdivides rice area, yield, and production by irrigated and non-irrigated area, as well as providing other data on irrigation development. The detailed RID data for the wet season is not fully consistent, when aggregated, with the MAC data on area and yields. Both sources, however, provide useful information and will be utilized with appropriate qualification where necessary.

Table 1 summarizes the official MAC data on rice area, yield, and production. As shown in the table, unlike other Southeast Asian countries such as Indonesia and the Philippines, Thailand continued to rely primarily on growth in rice area harvested, rather than yield growth, as the main source of growth in rice production through the mid-1970s. The rate of growth in area, however, has declined significantly since then, with improved yield growth accounting for nearly half of production growth. Based on three-year averages centered on the specified years, the rate of growth in rice area harvested was 2.2 percent per year from 1962/63 to 1974/75, and 1.4 percent per year from 1974/75 to 1986/87. During the first of these periods, yield growth was virtually stagnant, at 0.24 percent per year, but has increased to about 1.0 percent per year since 1974/75.

As can also be seen in Table 1, much of the impetus for overall yield growth in this latter period has come from growth in dry season area and yield. Yields in the dry season have increased at a rate of 1.5 percent per year, and dry season area has increased from 4 percent to 6.4 percent of total harvested area since 1974/75. Yields in the wet season have increased at only 0.8 percent per year during the same period.

3. TRENDS IN IRRIGATED RICE AREA AND YIELD

Tables 2 and 3 break down wet and dry season areas and yields by irrigated and non-irrigated area harvested, based on RID data. As was noted above, the area data for the wet season in Table 2 is not fully consistent with the data from Table 1. In particular, the RID data are nearly identical in the early 1960s, but tend to understate total wet season area by 1-3 percent annually in the mid-1970s, and overstate this area by a comparable margin in the early 1980s, before again converging beginning in the mid-1980s. Nevertheless, the relationship between irrigated and non-irrigated areas in the RID data appears to be consistent over time. Table 4 provides an alternative measure of irrigation development, state irrigation project areas where construction has been completed. The trends in irrigation development implied in Table 4 will be compared to that in the preceding tables.

As shown in Table 2, the growth rate in area irrigated in the wet season has been much faster since the mid 1970s than the growth rate in rainfed wet season area. From 1962/63 to 1974/75, wet season irrigated area grew at a rate of 1.3 percent per year, while total wet season area grew by 1.5 percent per year (all years again refer to three-year averages centered on that year). However, between 1974/75 and 1986/87, the rate of growth of wet season area irrigated was 2.2 percent, compared to only 1 percent for rainfed wet season area. Dry season area has virtually doubled since 1975/76, with most of the growth provided by irrigated area (Table 3).

Irrigated yields in the wet season have increased slowly from about 2.5 mt/ha in the 1970s to over 3.0 tons per hectare by 1986/87 , while unirrigated wet season rice yields have remained stagnant (Table 2). Since the early 1980s, the dry season crop has contributed more than 2 million mt of rice per year, which is over 10 percent of the total rice output. The effect of irrigation has not been only to expand the rice planted area by making dry season cropping possible, but also to increase rice yields, because irrigation has induced a shift in planting technique from broadcasting to transplanting, and because of complementarities with the use of new high-yielding rice varieties, fertilizer, and other chemical inputs.

Because of the improved cropping systems in dry season irrigated areas, the yield difference between irrigated and unirrigated areas in the dry season has been higher than in the wet season. Irrigated yields in the dry season have increased from about 3.00 mt/ha in 1974/75 to nearly 4.00 mt/ha in 1987/88, while, similar to the rainfed wet season case, non-irrigated yields in the dry season have been virtually stagnant since the mid-1970s.

4. TRENDS IN IRRIGATED AREA CONSTRUCTION AND BUDGETS

There are two main types of irrigation projects in Thailand, state irrigation projects, and people's projects. State projects are primarily medium to large gravity flow projects constructed or contracted out by the RID. People's projects are small projects, such as weirs, canal rehabilitation, drainage structures, pumps, and tanks that require small budgets and relatively simple technology. These small projects often supply water to remote rural areas for consumption, livestock, vegetable growing in the dry season, and fishery, in addition to supplementary water for at least one rice crop or other crops each year. The government has a policy to provide assistance for the maintenance of people's irrigation projects as well as the construction of new projects which are initiated by local farmers, who contribute money, labor or materials toward the construction. The construction of small projects which do not require large equipment or a high level of technology are the responsibility of the Department of Local Administration in the Ministry of Interior, while larger projects requiring more complex technology are constructed by the RID and then transferred to the Department of Local Administration for maintenance. Virtually all of the people's projects have been undertaken in the northern region of Thailand. Data on people's projects are sparse, but there is estimated to have been about 350,000-400,000 ha in these projects by the mid-1980s.

Area data is much more complete on state irrigation projects. Table 4 shows the regional breakdown of the government's irrigation development program during 1950-87, defined as state irrigation project areas where construction work has been completed. Table 5 summarizes the area completion data and the RID financial budget for irrigation by economic development plan, and Tables 6-8 present the detailed composition of the RID budget by expenditure category.

The irrigation construction area completed, which can be interpreted as a measure of potential irrigated service area, increased from 0.59 million ha in 1950 to 3.91 million ha in 1987 (Table 4). It is immediately apparent in comparing Table 4 to Tables 2 and 3 that irrigated area completions have increased much more rapidly than effective irrigated rice area harvested. A dramatic decline in effective rice area irrigated as a percentage of completed irrigated service area is indicated, particularly in the wet season. For example, in 1975/76, wet season irrigated rice area was 87 percent of completed irrigated area construction, but by 1987/88 was only 62 percent of completed area. Newly constructed irrigation areas during this period have not been as efficiently transformed into cropped areas as in earlier years.

It is useful to subdivide the irrigation construction program detailed in Table 4 by successive national economic and social development plans. During the period 1950-60, which is prior to the introduction of the national economic and social development plan, irrigated areas expanded at an average rate of 5.8 percent per year. The growth rate increased to 7.8 percent per year during the first development plan period, when the construction of many large irrigation projects which began in the late 1940s and early 1950s was being completed and the projects started to benefit planted areas.

During the period of the second development plan, however, the growth rate of irrigated areas dropped to 1.9 percent per year, because many projects started during the first plan were still under construction. This was partly due to the delay in construction which was a result of poor management and a lack of coordination among responsible units, as well as a lack of capital which led to a decline in the irrigation construction budget for both state and people's projects beginning in 1971 and continuing through the third plan (Tables 5-7).

At the end of the second plan period, irrigated areas were short of the target by about 300,000 ha. Moreover, the benefits derived form the irrigated areas were smaller than expected. Less than one-fourth of the wet season rice planted areas were irrigated, and dry season rice and upland crops were grown in only about 9.5 percent of the total irrigated areas. Only 12 percent of the state irrigated areas were planted with dry season rice crops.

Irrigated areas expanded more rapidly during the period of the third development plan (1972-76), at 7.3 percent per year, as previous projects came into completion. However, despite a change in irrigation policy direction to give more attention to medium and small projects, mostly to provide a more complete water distribution system in the areas of existing large projects, the irrigation construction budget continued to decline during the third plan period. This, coupled with administrative delays in disbursing the allocated budgets, resulted in a delay in the construction of many projects. Some planned projects were not started and the ditches and dikes projects did not significantly expand the area receiving irrigation water.

Consequently, most projects which began construction during the second and third plan periods were not completed until the fifth or even sixth plan periods. The expansion of irrigated areas in the fourth plan period (1977-81) therefore slowed down to 5.6 percent per year and in the first half of the fifth plan to 3.0 percent per year.

The change in irrigation policy emphasis from large to small and medium size projects in the third plan period benefited some areas which, although they were already classified as irrigated, did not previously benefit much from the projects due to the lack of water distribution system at the farm level. The construction of ditches and dikes as well as tertiary canals and drainage systems brought more rice land into cultivation, especially in the dry season. However, the benefits of such construction were not as great as expected. Even in the Chao Phya project, where large amounts of capital were invested, only about 40 percent of the area was cropped in the dry season.

4.1 Types of Irrigation

Surface water or gravity flow irrigation is predominant in Thailand. It is only recently that groundwater irrigation has developed by the government in the Yom river basin. Irrigation works are mostly in the form of the diversion of water from the canals or rivers to supplement the rain in rice areas. The method of diverting water by conserving it in large plains or building dams and distribution canals and laterals is practiced in every region of the country, according to geographical conditions of the area and the budget of the government.

The Royal Irrigation Department has classified irrigation into four categories according to the completeness of the water delivery system and the extent to which it benefits dry season cropping. Tables 9 and 10 summarize the distribution of irrigation systems by type of system and region for two years, 1978/79 and 1986/87.

Category 1 includes a complete irrigation system with land consolidation, or the development of farm land with the emphasis on water control. Land consolidation includes the construction of minor irrigation and drainage systems and farm roads, leveling of land, and realignment to reduce fragmentation. A complete system consists of diversion dams or storage reservoirs, the main water distribution and control system, and secondary and tertiary ditches and dikes in leveled and rectangular fields. The area under category 1 is irrigated and double cropped, and covered about 275,000 hectares, or about 8 percent of the total irrigated area, in 1986/87 (Table 10).

Category 2 irrigation systems have ditches and dikes, but have not undergone land consolidation, so the rice paddy is neither properly leveled nor rectangular. The ditches and dikes are constructed along the original boundaries of the rice field, mainly to deliver water to the fields and drain it out. The area under this category covered 1.57 million hectares or 45 percent of the total irrigated area in 1986/87.

Although a Category 3 irrigation is a complete system, it does not include land consolidation or ditches and dikes. In this category, diversion dams, main canals, and storage reservoirs provide irrigation water for wet season cropping. However, water is rarely supplied for dry season cropping, because most farms have no water control system. The total area under this category in 1986/87 was 1.17 million hectares or 33 percent of the total irrigated area. Under Category 4, some of the irrigation system has been constructed but a full canal network is not complete. The area under this category totalled 499,000 hectares, or 14 percent of the total irrigated area in 1986/87.

As was noted above, apart from state irrigation projects, there are people's irrigation projects which are small projects, such as weirs, canal rehabilitation, drainage structures, pumps, and tanks that require small budgets and unsophisticated technology for construction. Detailed data such as that provided in Table 10 for state irrigation projects is not available for people's projects.

4.2 Regional Distribution of Irrigated Area

Irrigated areas are unequally distributed among regions. The concentration of the government's irrigation investment has been in the Central Plain, because this area is the most important rice producing area in the country. The surplus rice available for exports comes from this region. The historical development of irrigation shows that the Central Plain has consistently received relatively more attention than other regions.

The inequality in the distribution of irrigated areas, however, has been reduced over time. In 1950, the Central Plain accounted for over 90 percent of total irrigated area, the North for 7 percent, and the Northeast and South less than one percent each (Table 4). The share of total irrigated area where construction has been completed in the Central region dropped to 50 percent in 1987, while it has increased for the North to 25 percent, the Northeast to 15 percent, and the South to 10 percent (Table 4). This has resulted from the policy to develop irrigation in other regions, particularly the North and Northeast, since the fourth plan period, although most of the large projects, such as the Greater Chao Phya and the Greater Mae Klong Projects, are still in the Central region.

Comparison of the regional distribution of irrigated areas by type in 1986/87 and 1978/79, also shows a more even distribution of area over time (Tables 9 and 10). Not only has the share of total irrigated area increased in the North, Northeast and the South between 1978/79 and 1986/87, but these regions also have a greater share of area in each category of irrigation, as well as a greater proportion of irrigated areas under more complete systems of water distribution and control.

4.3 Irrigated Area and Yield by Region

The extent to which the wet season rice planted area is irrigated can be indicated by the ratio of total irrigated area to wet season rice planted areas. As was shown above, nationally this ratio has increased slowly over time. Even in 1987/88, less than one-third of the wet season rice planted area was irrigated, and most of this area was in the Central region. Table 11 shows the while over 50 percent of the total wet season rice planted area is in the Northeast and 20 percent in the Central region, the ratio of total area irrigated to the wet season rice planted area is highest (102 percent) in the Central and lowest (9 percent) in the Northeast.

In the dry season, irrigated rice planted area has almost doubled between 1975 and 1987, and accounts for almost all of the dry season rice planted area in the whole kingdom. The dry season area has expanded more rapidly in 1970s than in 1950s or 1960s. Such an expansion in the dry season cropping area would not have been possible without improved water distribution system at the farm level. This can be partly attributed to the changes in irrigation policy emphasis from concentrating on large investment projects to a greater emphasis on small and medium size projects to improve water control at the farm since 1972.

For the dry season rice crop, about 80 percent of the planted area is in the Central region, particularly in the Chao Phya Project area (Table 11). This is due to the fact that the irrigation systems are most complete in this region (over 50 percent of the irrigated area in the Central is under Categories 1 and 2) and water availability for the dry season crop is greater than in other regions. However, only one-fourth of the irrigated area is double cropped in the Central region, which seems to be due to limited irrigation water supply from the Bhumiphol and Sirikit reservoirs, which prevents a fuller use of the complete system, as well as to the incomplete water delivery systems at the farm level, and to a lack of proper maintenance of the canals. Despite these constraints, over 80 percent of the total irrigated dry season planted areas

for rice and upland crops are concentrated in the Chao Phya and Mae Klong Project areas, and over 80 percent of the area cropped is under rice (Table 12).

5. DETERMINANTS OF IRRIGATION INVESTMENT IN THAILAND

The government of Thailand has broadened its policy objectives in the rice sector from an overriding concern with generation of revenues and foreign exchange to a more balanced approach which includes these goals together with concern over stable consumer and farm prices for rice and sustained growth in farm income. The irrigation investment program is one of the policy instruments to meet these objectives. Irrigation investment, however, must compete with a range of other agricultural and non-agricultural investments as a priority for government funding.

If the government is acting rationally, at least in the short run, the allocation of funds among these alternative investments will be influenced by the rate of return to these investments, within the constraints imposed by the availability of public revenues. Given the competition for scarce investible funds among alternative public investments and the continued importance of the objective to generate foreign exchange, it is hypothesized here that government investment in irrigation will take into account (a) the relative cost-effectiveness of the alternative investments, and in particular, the returns to investment in irrigation; (b) the availability of public resources; and (c) the potential for generating foreign exchange.

5.1 Model Specification

The model to be tested hypothesizes that the annual expenditures on construction of new state and people's irrigation systems in Thailand are a function of factors which determine the profitability or cost-effectiveness of new irrigation systems, the availability of public resources, and the potential for generation of foreign exchange. The variables tested in the regression specifications of the irrigation investment model are the real world price of rice, which affects the profitability of irrigation and the generation of foreign exchange; the real capital cost per hectare for developing new state irrigation systems, which affects profitability; the real GNP, which is a proxy for the availability of public resources; and the level of Thai exports of rice, which represent the potential for generation of foreign exchange. The export level is hypothesized to have a negative relationship with the level of irrigation investment. This is the expected relationship, because it is hypothesized that when the export level is increasing, it is taken as a signal that there will be downward pressure on world prices and foreign revenues. As a result, the government will tend to cut back on investments in order to reduce domestic supplies, exportable surpluses, and the downward pressure on world prices.

The irrigation investment functions are specified using a standard partial adjustment model, with the dependent variable appearing with a one-year lag as an independent variable A simple expectational structure is assumed, with the expected values of the variables representing irrigation investment profitability and foreign exchange earnings potential (rice price, capital costs per ha, and exports) assumed to be the actual values from the previous year. The GNP variable, which reflects the government's resource position, is specified with no lag, as is assumed to have an immediate impact on the level of irrigation investment expenditures.

The partial adjustment model implies that the full effect of changes in the independent variables on the dependent variables takes place over a number of years, with the duration of the lagged impact a function of the estimated parameters. This lagged response of investment to changes in the independent variables appears appropriate, given the lags in the irrigation development process, including lags between project appraisal and approval, between approval and initiation of construction, and between initiation and completion of the construction.

5.2 Data Sources and Definition of Variables

The variables utilized in the various specifications of the regression model are defined in Table 13. The sources for the basic data are as follows: (a) Royal Irrigation Department for real annual expenditures on new state and peoples irrigation construction and real capital costs per hectare for new construction of state irrigation projects; (b) Ministry of Agriculture for rice yield; (c) the World Bank for the exchange rate, the real world price of rice, and GNP; and (d) FAO Trade Yearbook for rice exports. The data are annual values for the period 1961-1987.

5.3 Results of Irrigation Investment Functions

The estimated irrigation investment functions for state and people's irrigation projects are presented in Table 14. The results for the state irrigation functions provide strong support to the hypothesis that investment in new irrigation construction is a function of the profitability or cost-effectiveness of new irrigation systems, the availability of government resources, and the potential for earning foreign exchange. The world price of rice has a statistically significant and strongly positive influence on new investment in state irrigation projects. The capital cost per hectare for state systems, as expected, has a statistically significant negative impact on new irrigation investment in state systems.

The level of real GNP, as hypothesized, has a highly significant positive impact on new irrigation investment. The rice export variable has the expected negative impact on irrigation investment, though the significance level is not as high as for the other variables. The lagged value of irrigation investment is highly significant statistically, and the value of the estimated parameters implies a long lag before adjustment to changes in the independent variables is complete.

The fit for the equations for people's irrigation systems is not as good as for the state systems. Although the independent variables all have the correct signs, the level of significance is generally not high. The primary reasons for the poorer fit are probably the following: first, the cost of state irrigation systems is used as a proxy for the cost of people's irrigation, because of the unavailability of time series data on the latter. Given the relatively poor fit, this variable is probably not a good proxy. Second, it is likely that the decisions to invest in people's projects are not as highly influenced by the variables utilized here. Political and social development objectives may be paramount for the small-scale people's projects, rather than the economic variables considered here.

6. SUMMARY AND CONCLUSIONS

Expansion of cropped area has been the major source of rice output growth in Thailand until mid-1970's when yield growth started to play a relatively more important role. Irrigation investment has contributed to both area and yield increases. Irrigated area completed has continued to increase from 0.59 million hectares in 1950 to 3.91 million hectares in 1987, at an average rate during the period of 5.3 percent per year.

6.1 Policy Directions in the Past

The purpose of early water resource development projects was to provide supplementary water for rice cropping in the wet season, resulting in an expansion of rice cropped area over and above that under rainfed conditions. After the second World War, a need to expand rice production to meet the rising export and domestic demand prompted irrigation policy towards the development of large projects which largely benefit the wet season crop. These include construction of a number of multi-purpose projects which, apart form irrigation benefits, also serve other purposes as flood control, hydroelectric power generation, saline water protection, navigation and fishery. The irrigation policy emphasis on large projects continued throughout the first and second national development plans (1961-66 and 1967-71, respectively).

The possibility of controlling water for the dry season became evident after the completion of the Bhumiphol Dam in the mid-1960s. This, together with the development in agricultural technology which resulted in rice varieties suitable for the dry season, led to a revision of irrigation policy objectives in the following development plan periods, from delivery of supplementary water to cropped area in the wet season to water delivery for cropping throughout the year. In addition, benefits from the large projects completed during the first two plan periods turned out to be smaller than expected, due to a lack of water delivery systems at the farm level. Consequently, there was a shift in investment priorities across types of irrigation works, with greater emphasis on small projects such as ditches and dikes, drainage canals and laterals in the existing large facilities, as well as small tanks and weirs throughout the water-shortage areas in the Northeast and North regions. Accordingly, there has been a significant drop in the real growth rates of irrigation budgets for large and medium projects since the third plan period. Such budgets grew at 4.6 percent per year in the fifth plan, compared to 14.2 percent in the first plan and 17.6 percent in the first and second plans.

6.2 Irrigation Benefits

The shift in irrigation policy emphasis from large to small and medium-size projects has benefitted some areas which were classified as irrigated but did not receive adequate water for cultivation. The construction of water distribution and drainage systems at farm level brought additional rice land into cultivation, especially in the dry season. This is evidenced by an expansion in the dry season rice cropped area since mid-1970's at a rate of 12 percent per year. The proportion of irrigated area planted with rice in the dry season almost doubled between the

early 1970s and mid-1980's, but even then, only about 20 percent of total irrigated area was under rice in the dry season for the country as a whole, and almost 30 percent for the Central region. The benefits of such projects for the dry season crops were not as great as expected, mainly because of inadequate supply of water stored and released from upstream reservoirs in most years due to insufficient rainfall in the wet season as well as to avoid conflict with the objective of hydroelectric power generation. Yield benefits, on the other hand, have been more significant. With the use of high yielding varieties, fertilizers and pesticides, wet and dry season yields in irrigated areas continued to increase beginning in the late 1970s, when area growth started to slow as constraints on cultivable land became more apparent.

The expansion of dry season cropping in irrigated areas has not been confined to rice. Since the mid-1980s, an increasing proportion has been under sugarcane and other upland crops, fruits and other horticultural products, as well as fish ponds. These nonrice agricultural activities accounted for about one-third of the dry-season irrigated cropped area in 1985 and more than 40 percent in 1986 and 1987. It should be noted, however, that farmers in irrigated areas, especially in the Central Plain, generally prefer to grow rice in the dry season as long as water is available. This is the case despite government encouragement to grow upland crops in the years when water may not be adequate for rice. Water is still a major determinant of the degree of diversification in each area, given that the rice price remains at an acceptable level.

Agricultural benefits from small tanks in the Northeast, on the other hand, have been relatively small compared to consumption and livestock benefits. This is due mainly to the limited capacity of the tanks to hold adequate water for agriculture, and also because dry season cropping is not usually practiced in the Northeast.

6.3 Present and Future Policy Directions

In accordance with the long-term policy of accelerating expansion of small irrigation projects in all regions of the country, RID was assigned the responsibility to construct such small water resource development works in 1977. The objectives of these small projects are to supply water to remote rural areas for consumption, livestock, vegetable growing in the dry season, fishery, and supplementary water for at least one rice crop or other crops each year. Farmers are required to participate in development of the projects as well as in their operation and maintenance.

By the time of the sixth development plan period (1987-91), most of the projects with low investment cost per hectare and high economic returns have been constructed. Further project development to open up new areas for irrigation will involve those with higher investment cost per hectare, due to geographical reasons. Realizing this, RID has changed its development priorities in the sixth plan to emphasize rehabilitation and maintenance of existing projects to improve water delivery, distribution, and drainage so that water can be made available in the amount and time required for the use of new agricultural technology. Other development directions include diversions of water from the Mae Klong to the Chao Phya river basin, a longer-term project to solve future water-shortage problems in the area. In addition,

there are plans for the further development of groundwater for agriculture, especially for crops requiring relatively small amounts of water in the dry season. Long-term investment planning for new projects will involve a more systematic development of the whole river basin, with greater considerations for the conditions of natural resources in the area.

Moreover, there are policies to develop water resources projects for consumption purposes, and for hydroelectricity generation to provide low cost energy for domestic use. Citizen participation in maintaining these projects is also strongly encouraged. Since evaluation of small projects in the Northeast has revealed relatively small agricultural benefits due to insufficient supply of water and a lack of maintenance by farmers' groups, these projects need to be reviewed in order that an improvement in the design, development and coordination in management of the projects, which will lead to greater benefits for cropping purposes. In view of a relatively recent diversification trend in the Northeast which involves a conversion of rainfed rice fields to mixed use including rice, upland high-value crops, and fish ponds, water-resources development in the region, especially small projects, may also contribute to such diversification activities.

Thai irrigation has thus evolved from a primary mission of building large, extensive projects for the benefit of low-input, wet season rice to a concern with improved water management and distribution of existing systems to facilitate intensified cropping of rice and other crops, and to construction of smaller-scale systems that are more adaptable to diversified cropping. As shown in the econometric analysis, these policy changes have occurred in response to direct economic incentives, including the declining world price of rice and the increasing costs of irrigation development, and in response to the rapid and diversified growth in Thai agriculture.

TABLES

Table 1: Rice area, yield, and production, Thailand, 1961/62-1986/87

Crop Year	Area			Yield			Production		
	Wet Season	Dry Season	Crop Year	Wet Season	Dry Season	Crop Year	Wet Season	Dry Season	Crop Year
	---------- '000 ha ---------			------- mt/ha ---------			--------- '000 mt ---------		
1961/62	6,168	11	6,179	1.60	1.71	1.60	9,867	19	9,886
1962/63	6,576	12	6,587	1.67	1.73	1.67	10,972	20	10,992
1963/64	6,584	13	6,597	1.76	1.65	1.76	11,563	22	11,585
1964/65	6,521	19	6,540	1.74	1.87	1.74	11,326	36	11,362
1965/66	6,532	23	6,554	1.67	2.04	1.68	10,932	46	10,978
1966/67	7,398	35	7,433	1.61	1.83	1.61	11,883	64	11,947
1967/68	6,606	52	6,658	1.44	2.34	1.45	9,504	121	9,625
1968/69	7,166	62	7,228	1.42	2.42	1.43	10,199	149	10,348
1969/70	7,584	87	7,584	1.74	2.41	1.77	13,201	209	13,410
1970/71	7,462	132	7,594	1.78	2.44	1.79	13,248	22	13,570
1971/72	7,312	215	7,527	1.81	2.43	1.83	13,223	521	13,744
1972/73	7,048	301	7,349	1.66	2.47	1.69	11,670	743	12,413
1973/74	8,037	326	8,363	1.73	3.10	1.78	13,886	1,012	14,899
1974/75	7,651	331	7,982	1.63	2.84	1.68	12,447	939	13,386
1975/76	8,519	377	8,896	1.65	3.20	1.72	14,090	1,208	15,300
1976/77	8,137	438	8,575	1.68	3.18	1.76	13,676	1,393	15,060
1977/78	8,554	477	9,031	1.44	3.33	1.54	12,335	1,586	13,921
1978/79	9,346	681	9,998	1.63	3.32	1.75	15,206	2,264	17,470
1979/80	9,099	336	9,435	1.61	3.30	1.67	14,646	1,111	15,757
1980/81	9,101	516	9,618	1.69	3.80	1.81	15,405	1,963	17,368
1981/82	9,023	572	9,595	1.75	3.52	1.85	15,758	2,017	17,774
1982/83	8,987	643	9,621	1.64	3.27	1.75	14,774	2,104	16,879
1983/84	9,298	717	10,015	1.82	3.63	1.95	16,943	2,606	19,549
1984/85	9,266	706	9,973	1.86	3.72	2.00	17,275	2,630	19,905
1985/86	9,510	638	10,148	1.89	3.66	2.00	17,930	2,334	20,264
1986/87	9,271	580	9,851	1.81	3.52	1.92	16,826	2,042	18,868
1987/88	8,626	731	9,357	1.77	3.79	1.93	15,271	2,770	18,041

Source: Agricultural Statistics of Thailand, various crop years, Office of Agricultural Economics, Ministry of Agriculture and Cooperatives

Table 2: Comparison of rice areas and yields in irrigated and unirrigated areas and the Whole Kingdom, wet season, Thailand, 1958/59-1983/84

Crop Year	Wet Season Area				Wet Season Yield			
	Irrig. Project Area	Outside Project Area	Whole Kingdom	Ratio of Proj. area to Whole Kingdom (%)	Irrig. Project Area	Outside Project Area	Whole Kingdom	Ratio of Production in Project Area to Whole Kingdom (%)
	---------- '000 ha ----------				-------- mt/ha ----------			
1958/59	1,363	4,395	5,758	23.67	2.23	0.90	1.21	43.5
1959/60	1,318	4,747	6,066	21.74	2.16	0.81	1.10	42.5
1960/61	1,370	4,552	5,922	23.13	2.57	0.93	1.31	45.4
1961/62	1,428	4,741	6,168	23.14	2.54	0.94	1.31	45.2
1962/63	1,629	5,019	6,648	24.50	2.54	1.02	1.39	44.7
1963/64	1,678	4,923	6,602	25.42	2.58	1.58	1.52	43.2
1964/65	1,762	4,778	6,539	26.94	2.29	1.16	1.46	42.2
1965/66	1,754	4,800	6,554	26.76	2.48	1.01	1.40	47.3
1966/67	1,768	5,664	7,432	23.79	2.52	1.32	1.61	37.3
1967/68	1,763	4,894	6,658	26.48	2.60	1.03	1.45	47.6
1968/69	1,768	5,459	7,227	24.46	2.52	1.08	1.43	43.1
1969/70	1,802	5,835	7,637	23.59	2.39	1.55	1.75	32.3
1970/71	1,838	5,963	7,802	23.56	2.42	1.50	1.72	33.2
1971/72	1,872	6,131	8,003	23.39	2.68	1.50	1.77	35.3
1972/73	1,808	5,331	7,139	25.32	2.55	1.32	1.63	39.5
1973/74	1,822	5,789	7,611	23.94	2.75	1.54	1.83	36.0
1974/75	1,856	5,472	7,328	25.33	2.51	1.45	1.72	37.0
1975/76	1,882	6,530	8,411	22.37	2.52	1.69	1.87	30.1
1976/77	1,914	6,526	8,440	22.67	2.78	1.72	1.96	32.2
1977/78	1,941	6,458	8,398	23.11	2.82	1.05	1.46	44.7
1978/79	2,035	7,242	9,277	21.94	2.76	1.41	1.71	35.5
1979/80	2,056	7,166	9,222	22.29	2.87	1.32	1.67	38.3
1980/81	2,061	7,742	9,803	21.02	2.97	1.42	1.75	35.7
1981/82	2,123	7,402	9,525	22.29	2.95	1.41	1.75	37.5
1982/83	2,192	7,021	9,213	23.79	3.06	1.28	1.70	42.8
1983/84	2,250	7,260	9,510	23.66	2.95	1.42	1.81	44.7
1984/85	2,317	6,953	9,266	25.00	3.09	1.46	1.86	41.3
1985/86	2,382	7,134	9,510	25.05	3.11	1.48	1.89	39.8
1986/87	2,387	6,883	9,270	25.75	3.06	1.38	1.82	43.4
1987/88	2,417	6,208	8,626	28.02	2.91	1.33	1.77	46.1

Source: Royal Irrigation Department

Table 3: Comparison of rice and yield in irrigated areas and the Whole Kingdom, dry season, Thailand, 1975-85

Crop Year	Dry Season Area				Dry Season Yield		
	Irrig. Project Area	Outside Project Area	Whole Kingdom	Ratio of Proj. Area to Whole Kingdom	Irrig. Proj. Area	Outside Proj. Area	Whole Kingdom
	-------- '000 ha --------			%	--------- mt/ha ----------		
1974/75	306	25	331	94.45	2.96	1.30	2.84
1975/76	370	7	377	98.14	3.23	1.65	3.20
1976/77	408	30	438	93.15	3.28	1.82	3.18
1977/78	407	70	477	85.32	3.60	1.74	3.33
1978/79	565	116	681	82.97	3.59	2.03	3.32
1979/80	260	76	336	77.38	3.87	1.38	3.30
1980/81	516	0	516	100.00	3.80	-	3.80
1981/82	572	0	572	100.00	3.52	-	3.52
1982/83	607	27	634	95.71	3.39	1.61	3.27
1983/84	607	110	717	84.68	3.99	1.67	3.63
1984/85	569	137	706	80.57	3.92	2.92	3.72
1985/86	509	129	638	79.78	3.73	2.69	3.52
1986/87	563	17	580	97.07	3.91	2.01	3.85

Source: Royal Irrigation Department

Table 4: State Irrigation Project areas where construction has been completed, Thailand, 1950-86

	REGION									
	North		Northeast		Central		South		Whole Kingdom	
Year	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
1950	42.88	7.22	0.96	0.16	545.44	91.89	4.32	0.73	593.60	100
1951	43.52	7.29	4.00	0.67	545.44	91.32	4.32	0.72	597.28	100
1952	47.20	7.75	8.00	1.31	546.88	89.80	6.88	1.13	608.96	100
1953	55.84	8.54	13.44	2.05	576.32	88.11	8.48	1.30	654.08	100
1954	57.76	8.43	14.88	2.17	596.96	87.09	15.84	2.31	658.44	100
1955	89.92	10.00	59.04	6.57	720.32	80.12	29.76	3.31	899.04	100
1956	90.88	9.64	79.68	8.45	742.72	78.76	29.76	3.15	943.04	100
1957	90.88	9.45	96.32	10.02	744.00	77.40	30.08	3.13	961.28	100
1958	90.88	9.20	123.20	12.47	744.00	75.29	30.08	3.04	988.16	100
1959	92.80	9.27	133.60	13.35	744.00	74.36	30.08	3.01	1,000.48	100
1960	92.80	9.14	134.08	13.20	758.40	74.69	30.08	2.96	1,015.36	100
1961	92.80	9.06	142.56	13.92	758.40	74.07	30.08	2.94	1,023.84	100
1962	103.68	9.57	144.00	13.29	792.16	73.14	43.20	3.99	1,083.04	100
1963	135.04	9.52	151.52	10.68	1,088.48	76.75	43.20	3.05	1,418.24	100
1964	135.04	8.86	155.20	10.18	1,191.04	78.13	43.20	2.83	1,524.48	100
1965	135.04	8.75	156.64	10.14	1,209.12	78.31	43.20	2.80	1,544.00	100
1966	137.44	8.88	158.72	10.25	1,205.92	77.88	46.40	3.00	1,548.48	100
1967	145.92	9.37	158.72	10.19	1,205.92	77.45	46.40	2.98	1,556.96	100
1968	145.92	9.34	161.28	10.32	1,205.92	77.19	49.12	3.14	1,562.24	100
1969	241.44	14.87	165.28	10.18	1,168.32	71.93	49.12	3.02	1,624.16	100
1970	241.44	14.43	174.40	10.42	1,206.72	72.12	50.72	3.03	1,673.28	100
1971	266.72	15.66	174.40	10.24	1,207.52	70.90	54.40	3.19	1,703.04	100
1972	290.40	16.14	174.72	9.71	1,279.84	71.13	54.40	3.02	1,799.36	100
1973	300.80	15.72	178.40	9.32	1,378.40	72.05	55.52	2.90	1,913.12	100
1974	360.80	17.78	190.08	9.37	1,381.92	68.09	96.64	4.76	2,029.44	100
1975	363.52	17.51	191.04	9.20	1,424.32	68.62	96.64	4.66	2,075.52	100
1976	391.04	16.23	224.96	9.34	1,627.68	67.58	164.96	6.85	2,408.64	100
1977	452.48	17.91	245.28	9.71	1,646.88	65.18	182.08	7.21	2,526.72	100
1978	491.36	18.40	277.44	10.39	1,672.96	62.65	228.48	8.56	2,670.24	100
1979	582.64	18.87	308.48	11.01	1,722.56	61.50	241.12	8.61	2,800.80	100
1980	574.72	19.71	340.80	11.69	1,743.52	59.81	256.16	8.79	2,915.20	100
1981	601.44	20.11	359.68	12.02	1,878.72	59.46	251.52	8.41	2,991.36	100
1982	660.16	20.87	406.40	12.85	1,827.04	57.75	269.92	8.53	3,171.52	100
1983	746.08	22.47	438.56	13.21	1,844.96	55.56	290.88	8.76	3,320.48	100
1984	817.76	23.60	473.44	13.66	1,855.04	53.54	318.88	9.20	3,464.96	100
1985	870.88	23.80	522.40	14.28	1,929.60	52.74	335.52	9.17	3,658.40	100
1986	934.56	24.45	579.04	15.15	1,947.68	60.96	360.96	9.44	3,822.24	100
1987	976.65	24.97	599.39	15.32	1,960.67	50.13	374.81	9.58	3,911.52	100

Source: Royal Irrigation Department

Table 5: Royal Irrigation Department real budget by plan period, 1976 prices, and State Project Area completions, Thailand, 1962-86

	Plan Period				
	1 1962-66	2 1967-71	3 1972-76	4 1977-81	5 1982-86
Budget item (million Baht)					
General	1,108.74 (16.87)[a]	3,120.54 (20.50)	4,491.64 (35.97)	5,107.17 (28.95)	6,256.78 (24.68)
Operation and maintenance	1,133.55 (17.24)	2,314.04 (15.20)	1,695.84 (13.58)	4,251.53 (24.10)	7,117.05 (28.07)
Construction:					
State Projects	3,701.41 (56.31)	7,317.69 (48.06)	4,066.59 (32.56)	5,567.89 (31.56)	8,254.98 (32.56)
People's Projects	629.63 (9.58)	2,473.09 (16.24)	2,234.48 (17.89)	2,714.27 (15.39)	3,726.84 (14.70)
Total Construction	4,331.04 (65.89)	9,790.78 (64.31)	6,301.07 (50.46)	8,282.18 (46.95)	11,981.82 (47.26)
Total Budget (million Baht):	6,573.33	15,225.36	12,487.62	17,640.88	25,355.65
Area Completed, State Projects ('000 ha)	524.64	154.56	705.60	582.72	830.88

[a] Figures in parentheses are percentage of total budget.

Table 6: Royal Irrigation Department annual budget at current prices, Thailand, 1961-87

Year	Total Budget	General	Operation & Maintenance	State Project	People's Project	Total Construction
	---------- million Baht ----------					
1961	351.52	40.87	48.67	228.96	33.02	261.98
1962	508.27	65.75	69.91	314.71	57.90	372.61
1963	573.72	59.20	84.61	365.72	64.19	429.91
1964	475.46	64.91	99.79	273.41	37.35	310.76
1965	695.57	172.95	129.06	332.43	61.13	393.56
1966	848.75	160.00	149.22	462.08	77.45	539.53
1967	1,195.68	173.00	206.85	705.42	110.41	815.83
1968	1,389.45	171.17	240.97	784.76	192.55	977.31
1969	1,604.95	213.60	274.45	867.91	249.00	1,116.91
1970	2,077.40	501.93	339.69	834.40	401.37	1,235.77
1971	1,972.04	631.22	189.76	766.23	384.83	1,151.06
1972	1,745.56	590.59	193.51	626.66	334.81	961.47
1973	1,393.23	571.89	186.19	393.30	241.85	635.15
1974	1,694.47	657.11	203.76	559.37	274.22	833.59
1975	2,489.20	851.08	336.76	877.10	424.27	1,301.37
1976	3,161.24	1,096.73	537.39	936.43	590.70	1,527.13
1977	3,381.89	1,179.11	591.88	909.30	701.61	1,610.91
1978	3,855.50	1,119.86	761.79	1,206.79	767.07	1,973.86
1979	4,451.40	1,306.33	1,256.90	1,506.80	381.36	1,888.16
1980	5,334.91	1,447.83	1,411.37	1,781.32	694.39	2,475.71
1981	7,237.03	1,858.04	1,960.19	2,306.72	1,112.08	3,418.80
1982	8,087.04	1,219.83	2,935.10	2,767.51	1,164.59	3,932.10
1983	8,578.67	2,195.51	2,197.26	2,938.69	1,247.21	4,185.90
1984	8,828.85	2,291.62	2,303.60	2,818.29	1,415.34	4,233.63
1985	9,123.83	2,453.84	2,425.98	2,808.98	1,435.04	4,244.02
1986	8,756.62	2,542.62	2,311.42	2,793.15	1,109.43	3,902.58
1987	8,393.16	2,643.93	2,411.60	2,139.86	1,197.76	3,337.62

Source: Royal Irrigation Department

Table 7: Royal Irrigation Department real annual budget at 1976 prices, Thailand, 1961-87

Year	Total Budget	General	Operation & Maintenance	Construction: State Projects	Construction: People's Projects	Construction: Total Construction
	million Baht					
1961	754.33	87.70	104.44	491.33	70.86	562.19
1962	1,028.89	133.10	141.52	637.06	117.21	754.27
1963	1,241.82	128.14	183.14	791.60	138.94	930.54
1964	1,095.53	149.56	229.93	629.98	86.06	716.04
1965	1,552.61	386.05	288.08	742.03	136.45	878.48
1966	1,654.48	311.89	290.88	900.74	150.97	1,051.71
1967	2,173.96	314.55	376.09	1,282.58	200.75	1,483.33
1968	2,636.53	324.80	457.25	1,489.11	365.37	1,854.48
1969	2,950.28	392.65	504.50	1,595.42	457.72	2,053.14
1970	3,832.84	926.07	626.73	1,539.48	740.54	2,280.02
1971	3,631.75	1,162.47	349.47	1,411.10	708.71	2,119.81
1972	2,978.77	1,007.83	330.22	1,069.39	571.35	1,640.74
1973	1,935.04	794.29	258.60	546.25	335.90	882.15
1974	1,825.04	708.09	219.57	602.77	295.50	898.27
1975	2,587.53	884.70	350.06	911.75	441.03	1,352.78
1976	3,161.24	1,096.73	537.39	936.43	590.70	1,527.13
1977	3,137.19	1,093.79	549.05	843.51	650.84	1,494.35
1978	3,329.45	967.06	657.85	1,042.13	662.41	1,704.54
1979	3,456.06	1,014.23	975.85	1,169.88	296.09	1,465.97
1980	3,448.55	935.90	912.33	1,151.47	448.86	1,600.33
1981	4,269.63	1,096.19	1,156.45	1,360.90	656.09	2,016.99
1982	4,729.26	713.35	1,716.43	1,618.43	681.05	2,299.48
1983	4,916.14	1,258.17	1,259.17	1,684.06	714.73	2,398.79
1984	5,221.08	1,355.19	1,362.27	1,666.64	836.98	2,503.62
1985	5,398.72	1,451.98	1,435.49	1,662.12	849.14	2,511.26
1986	5,090.45	1,478.09	1,343.69	1,623.73	644.94	2,268.67
1987	4,793.21	1,509.91	1,377.23	1,222.04	684.02	1,906.26

Source: Royal Irrigation Department

Table 8: Composition of Royal Irrigation annual budget

Year	Total Budget	General	Operation & Maintenance	Construction: State Projects	Construction: People's Projects	Construction: Total Construction
	----------	----------	Percent	----------	----------	
1961	100.00	11.63	13.85	65.13	9.39	74.52
1962	100.00	12.94	13.75	61.92	11.39	73.31
1963	100.00	10.32	14.75	63.75	11.19	74.94
1964	100.00	13.65	20.99	57.50	7.86	65.36
1965	100.00	24.86	18.55	47.79	8.79	56.58
1966	100.00	18.85	17.58	54.44	9.13	63.57
1967	100.00	14.47	17.30	59.00	9.23	68.23
1968	100.00	12.32	17.34	56.48	13.86	70.34
1969	100.00	13.31	17.10	54.08	15.51	69.59
1970	100.00	24.16	16.35	40.17	19.32	59.49
1971	100.00	32.01	9.62	38.85	19.51	58.36
1972	100.00	33.83	11.09	35.90	19.18	55.08
1973	100.00	41.05	13.36	28.23	17.36	45.59
1974	100.00	38.78	12.02	33.01	16.18	49.19
1975	100.00	34.19	13.53	35.24	17.04	52.28
1976	100.00	34.69	17.00	29.62	18.69	48.31
1977	100.00	34.87	17.50	26.89	20.75	47.64
1978	100.00	29.05	19.76	31.30	19.90	51.20
1979	100.00	29.35	28.24	33.85	8.57	42.42
1980	100.00	27.14	26.46	33.39	13.02	46.41
1981	100.00	25.67	27.09	31.87	15.37	47.24
1982	100.00	15.08	36.29	34.22	14.40	48.62
1983	100.00	25.59	25.61	34.26	14.54	48.80
1984	100.00	25.96	26.09	31.92	16.03	47.95
1985	100.00	26.89	26.59	30.79	15.73	46.52
1986	100.00	29.04	26.40	31.90	12.67	44.57
1987	100.00	31.50	28.73	25.50	14.27	39.77

Source: Royal Irrigation Department

Table 9: Irrigated area by category and region, 1978/79[a]

Category	North			Northeast			Central Region			South			Whole Kingdom		
	Area	% of all area under category	% of area in Whole Kingdom	Area	% of all area under category	% of area in Whole Kingdom	Area	% of all area under category	% of area in Whole Kingdom	Area	% of all area under category	% of area in Whole Kingdom	Area	% of all area under category	% of area in Whole Kingdom
	('000ha)			('000ha)			('000ha)			('000ha)					
1	-	-	-	2.50	0.98	7.73	29.80	1.61	92.27	-	-	-	32.30	1.26	100.00
2	129.56	48.55	10.44	72.10	28.26	5.81	1018.16	54.90	82.07	20.76	11.58	1.67	1240.58	48.54	100.00
3	62.83	23.55	7.26	106.89	41.90	12.35	593.58	32.00	68.60	101.95	56.89	11.78	865.25	33.85	100.00
4	74.45	27.90	17.82	73.63	28.86	17.63	213.15	11.49	51.02	56.51	31.53	13.53	417.74	16.34	100.00
Total	266.84	100.00	10.44	255.12	100.00	9.98	1854.70	100.00	72.57	179.22	100.00	7.01	2555.88	100.00	100.00

[a] Category 1 includes those projects with a complete irrigation system and land consolidation. Category 2 includes those projects with a complete irrigation system and ditches and dikes. Category 3 includes those projects with a complete irrigation system but neither land consolidation nor dikes and ditches. Category 4 projects have only incomplete irrigation systems.

Source: Thailand, Ministry of Agriculture and Cooperatives, Royal Irrigation Department, Report on Rice Production in Irrigation Project Areas, 1978/79 (Bangkok: Ministry of Agriculture and Cooperatives, 1979)

Table 10: Irrigated area by category and region, Thailand 1986/87[a]

Category	North			Northeast			Central Region			South			Whole Kingdom	
	Area	% of area in region	% of area in category	Area	% of area in region	% of area in category	Area	% of area in region	% of area in category	Area	% of area in region	% Area in category	Area	% of area in region
	('000ha)			('000ha)			('000ha)			('000ha)				
1	117	23	43	55	12	20	103	5	37	0	0	0	275	8
2	169	34	11	171	38	11	1148	51	73	77	23	5	1565	45
3	86	17	7	157	35	13	821	37	70	102	31	9	1166	33
4	126	25	25	62	13	12	158	7	32	153	46	31	499	14
Total	498	100	14	445	100	13	2230	100	64	332	100	9	3505	100

[a] Category 1 includes those projects with a complete irrigation system and land consolidation. Category 2 includes those projects with a complete irrigation system and ditches and dikes. Category 3 includes those projects with a complete irrigation system but neither land consolidation nor dikes and ditches. Category 4 projects have only incomplete irrigation systems.

Source: Royal Irrigation Department

Table 11: Irrigated and rice planted areas by region, 1983 (dry season, 1982/83 and wet season, 1983/84), Thailand

	North	Northeast	Central	South	Whole Kingdom
Irrigated area ('000 ha)	695.52 (20.78%)	447.68 (13.38%)	1,884.80 (56.32%)	318.72 (9.52%)	3,346.7 (100.0%)
Rice planted area ('000 ha):					
a) Wet season	2,059.04 (22.14%)	4,819.68 (51.83%)	1,840.16 (19.79%)	579.52 (6.23%)	9,298.4 (100.0%)
b) Dry season	66.56 (10.50%)	35.04 (5.53%)	506.88 (79.94%)	25.60 (4.04%)	634.08 (100.0%)
% Irrigated area / Wet season planted area	33.78	9.29	102.42	55.00	35.99
% Dry season planted area / Irrigated area	9.57	7.83	26.89	8.03	18.95
% Double cropping rice area	3.23	0.73	27.54	4.42	6.82

Source: Office of Agricultural Economics, Ministry of Agriculture and Cooperatives, Agricultural Statistics of Thailand, crop year 1984/85

Note: Numbers in parentheses represent percentages.

Table 12: Dry season cropping in the Chao Phya and Mae Klong project areas, Thailand 1967-85

Year	Chao Phya Project			Mae Klong Project			Percent of (1+2) in Total Irrigation Project Area		
	Rice	Upland Crops	Total	Rice	Upland Crops	Total	Rice	Upland Crops	Total
	'000 hectares								
1967	21	14	35						
1968	35	10	45						
1969	35	10	45						
1970	44	14	59						
1971	64	8	72						
1972	82	12	94						
1973	129	14	143						
1974	206	16	222						
1975	263	17	290	8			89		
1976	278	17	295	12			91		
1977	370	14	384	18			92		
1978	351	n.a.	n.a.	19			91		
1979	489	n.a	n.a.	26			91		
1980	209	n.a.	n.a.	17			87		
1981	504	n.a.	n.a.	26			92		
1982	545	10	555	33	18	51	91	30	83
1983	514	21	535	31	22	53	90	40	82
1984	509	26	535	32	23	55	89	40	81
1985	468	22	490	33	18	51	88	37	80

Source: Royal Irrigation Department

Table 13: Definition of variables for estimation of irrigation investment functions in Thailand. All variables are on an annual basis, 1961-1987

Variable	Definition
STEXP	Real expenditures on new state irrigation construction, thousand US$, 1985 prices.
PEXP	Real expenditures on new people's irrigation construction, thousand US$, 1985 prices.
WPRICE	Real world rice price, Thai 5% broken, FOB Bangkok, US$/mt, 1985 prices.
COSTHA	Real capital costs per ha for new state irrigation construction, thousand US$, 1985 prices.
GNP	Gross national product, million US$, 1985 prices.
EXPORT	Rice exports, 1000 mt, milled equivalent.

Table 14: Irrigation investment functions for state and people's irrigation projects, Thailand

(3)	Dependent Variables (4) STEXP	STEXP	PEXP	(1) (2) PEXP
Constant	-3138.51 (-0.27)[a]	23585.50 (1.29)	-100.03 (-0.46)	16.15 (0.43)
$WPRICE_{t-1}$	72.99 (4.85)	48.01 (2.44)	0.57 (1.66)	0.44 (0.92)
$COSTHA_{t-1}$	-20.05 (-4.98)	-25.62 (-5.26)	-0.125 (-1.21)	-0.146 (-1.23)
GNP_t	1.20 (3.98)	2.18 (3.59)	0.014 (2.09)	0.019 (1.34)
$EXPORT_{t-1}$		-9.86 (-1.84)		-0.048 (-0.39)
$STEXP_{t-1}$	0.875 (10.78)	0.833 (10.36)		
$PEXP_{t-1}$			0.793 (4.11)	0.773 (3.80)
Adj. R^2	0.87	0.88	0.74	0.73
Durbin Watson	2.14	2.07	1.77	1.82

[a] t-statistics are in parentheses.

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