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Status and Performance of Irrigation in Thailand

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Rice Policies in
Southeast Asia
Project

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IN THAILAND

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FOREWORD

The Rice Policies in Southeast Asia Project is a collaborative effort involving the International Food Policy Research Institute, the International Rice Research Institute, the International Fertilizer Development Center, and researchers and institutions in Indonesia, Malaysia, the Philippines, and Thailand.

As part of the project, a series of working papers was commissioned to provide an overview of the status, performance, and prospects of irrigation in the four countries. The papers review and summarize available information on the area, yield, production, and cropping intensity impact of rice-based irrigation and make preliminary assessments of long-term irrigation development prospects based on past trends and government investment plans. The papers in this series represent revised versions of papers originally presented at the Workshop on Rice Policy in Southeast Asian Countries, Los Baños, Philippines, May 22-25, 1979.

The working papers are intended to sketch the broad dimensions of irrigation development in the four countries and to identify key issues for further study, rather than to provide original analysis of these issues. Rigorous analysis of several of the important issues, including the income distribution impact of irrigation and the relative efficiency of investment in irrigation schemes of alternative sizes, water sources, and water allocation systems, is now under way by researchers at IFPRI and in the collaborating countries.

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in Southeast Asia Project
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1. INTRODUCTION

Although rice maintained its dominant position in Thai agriculture, both in its use of resources and in its contribution to export earnings and GDP (Table 1), its production growth during the period 1954-78 averaged only 4.8 percent per year. This was slower than the production growth of cassava (20.9 percent per year), sugarcane (11.8 percent per year), and maize (20.6 percent per year).^{1/}

The growth rate of production of wet-season rice has slowed over the years. During the 1970s it was only 1.42 percent per year -- lower than the population growth of 2.8 percent per year. Thus, in order to ensure an adequate supply of rice, not only for domestic consumption but also for exports, it is necessary to expand rice output as much as possible.

An increase in rice production could be achieved either by expanding the cropping area or by increasing the yield per unit of area planted. Irrigation is important to both. The availability of water determines whether additional land can be brought into cultivation or, if suitable land has been exhausted, whether more intensive use of land is practicable. And proper water control reduces the uncertainty associated with weather conditions (rainfall), enhances the effectiveness of fertilizer and insecticide application, and encourages the adoption of new high-yielding varieties and farm mechanization, all of which makes yield increases possible.

The Thai government has shown its awareness of the importance of irrigation since it drew up the First National Development Plan (1961-66). The major objective of investing in large irrigation projects then was to increase the wet-season rice output. It was not until almost a decade later, after the limitations of expanding the cropping area and yield of wet-season rice became known, that the possibility of increasing rice output by expanding the dry-season cropping area became evident. That is, rice yields could be increased by double cropping and by better water control in the dry season. To do this, the Thai government shifted the emphasis in the Third Plan (1972-76) to small-scale irrigation projects, such as ditches and dikes, feeder roads, and leveling of the land to improve the area where a large infrastructure has already been constructed. This has significantly increased the dry-season cropping area for rice in recent years, especially in the Central Plain (Table 2). As a result, the declining growth of rice output was reversed in the 1970s.

^{1/}These figures are calculated from the production data of the Ministry of Agriculture, Office of Agricultural Economics, Bangkok.

Table 1--Planted area, production, and contribution of selected crops to agricultural value added and export earnings, selected years

| Crop | Planted Area | | | Production | | | Contribution to Agricultural Value Added | | | Contribution to Total Agricultural Export Value | | |
|-----------|--------------------|--------------------|--------------------|-----------------------|---------------------|---------------------|--|-------|-------|---|-------|-------|
| | 1972/73 | 1975/76 | 1978/79 | 1972/73 | 1975/76 | 1978/79 | 1973 | 1976 | 1979 | 1973 | 1976 | 1979 |
| | (million hectares) | | | (million metric tons) | | | (percent) | | | | | |
| Rice | 7.14 ^{a/} | 8.52 ^{a/} | 9.35 ^{a/} | 11.67 ^{a/} | 14.09 ^{a/} | 15.21 ^{a/} | 35.21 | 29.60 | 29.77 | 15.75 | 18.71 | 22.82 |
| Maize | 1.00 | 1.32 | 1.39 | 1.32 | 2.86 | 2.79 | 4.20 | 4.08 | 4.55 | 12.86 | 12.15 | 8.26 |
| Cassava | 0.33 | 0.59 | 1.01 | 6.89 | 7.10 | 15.05 | 4.04 | 5.44 | 5.75 | 10.99 | 16.11 | 14.47 |
| Sugarcane | 0.18 | 0.39 | 0.51 | 9.51 | 19.91 | 20.56 | 3.73 | 6.23 | 3.29 | 6.42 | 15.74 | 7.94 |
| Soybeans | 0.08 | 0.12 | 0.16 | 0.07 | 0.11 | 0.16 | 0.65 | 0.89 | 1.08 | 0.33 | 0.10 | 0.10 |
| Rubber | 0.88 | 1.34 | 1.51 | 0.34 | 0.38 | 0.47 | 3.09 | 2.70 | 3.18 | 19.81 | 11.34 | 15.48 |

Sources: Thailand, Ministry of Agriculture and Cooperatives, Division of Agricultural Economics, Agricultural Statistics of Thailand, Crop Years 1972/73, 1975/76, 1978/79 (Bangkok: Ministry of Agriculture and Cooperatives, 1974, 1976, 1979); and Thailand, Office of the National Economic and Social Development Board, Office of the Prime Minister, National Income of Thailand, 1978, 1979 (Bangkok: NESDB, 1979, 1980).

^{a/}Wet season only.

Table 2--Area planted with dry-season rice by region, 1960-79

| Year | North | Northeast | Central Plain | South | Whole Kingdom |
|------|------------------|-----------|---------------|-------|---------------|
| | (1,000 hectares) | | | | |
| 1960 | 4.28 | 0.12 | 5.77 | 0.14 | 10.31 |
| 1961 | 4.30 | 0.61 | 6.26 | 0.08 | 11.25 |
| 1962 | 5.06 | 0.12 | 6.26 | 0.08 | 11.53 |
| 1963 | 6.73 | 0.24 | 6.20 | 0.13 | 13.31 |
| 1964 | 5.89 | 0.32 | 10.49 | 2.56 | 19.26 |
| 1965 | 8.79 | 0.07 | 11.18 | 2.51 | 22.55 |
| 1966 | 10.53 | 3.41 | 18.71 | 2.35 | 35.00 |
| 1967 | 13.55 | 1.04 | 34.70 | 2.52 | 51.81 |
| 1968 | 13.75 | 1.17 | 42.36 | 4.32 | 61.60 |
| 1969 | 20.00 | 2.14 | 60.12 | 4.62 | 86.88 |
| 1970 | 19.99 | 3.07 | 103.58 | 5.42 | 132.05 |
| 1971 | 24.59 | 4.83 | 178.08 | 7.01 | 214.52 |
| 1972 | 20.95 | 5.60 | 266.93 | 7.77 | 301.25 |
| 1973 | 14.59 | 2.56 | 185.60 | 6.61 | 209.36 |
| 1974 | 30.13 | 9.67 | 253.15 | 11.93 | 304.88 |
| 1975 | 49.12 | 11.59 | 327.00 | 22.38 | 410.08 |
| 1976 | 59.59 | 7.57 | 373.73 | 17.84 | 458.73 |
| 1977 | 44.20 | 5.75 | 421.36 | 18.33 | 489.64 |
| 1978 | 61.69 | 26.30 | 381.43 | 20.18 | 489.60 |
| 1979 | 79.81 | 90.54 | 454.69 | 18.74 | 643.77 |

Sources: Thailand, Ministry of Agriculture and Cooperatives, Rice Department, Annual Report on Rice Production in Thailand, various issues (Bangkok: Ministry of Agriculture and Cooperatives, various years) (in Thai); Thailand, Ministry of Agriculture, Division of Agricultural Economics, Center for Agricultural Statistics, "Report on the Survey of Dry Season Rice Production, 1977/78, 1978/79," Bangkok, 1978, 1979 (mimeographed, in Thai); and Thailand, Ministry of Agriculture, Division of Agricultural Economics, Center for Agricultural Statistics, unpublished data.

The future prospects for increasing rice supply depend largely on the government's strategies and timing for irrigation development, as well as on other agricultural policies, such as price controls, agricultural credit programs, and other extension services.

2. AN OVERVIEW OF THE HISTORICAL DEVELOPMENT OF IRRIGATION IN THAILAND

Early water control practices were initiated through the cooperative efforts of local people long before the state took action. Irrigation systems in the past consisted mainly of diversion irrigation and canal irrigation. Diversion weirs were constructed on a small-scale, temporary basis largely in the northern valleys and provinces of the Central Plain. Canal irrigation, on the other hand, was concentrated from the lower part of the Central Plain down to the Gulf of Thailand. Although most small canals were dug by local farmers to divert water into the fields, larger canals were dug by the government during the Chakri Dynasty mainly for water transport and communications. The water from many of these canals, which included canals within cities, shortcut canals, and canals joining parallel rivers, could reach the fields only when the river overflowed. Some of the major canals are still in use today.

Present-day irrigation systems were not begun until 1889, in the reign of King Rama V, when a concession was given to the Siam Canals, Land and Irrigation Company to dig canals and to construct gates, drainage structures, and ditches and dikes in the lower Chao Phya Basin (Rangsit area) in the Central Plain of Thailand. However, because no dams were constructed, water was not directly diverted into the fields.

In 1903 the Department of Canals was established in the Ministry of Agriculture. The department was responsible for navigation and for planning irrigation projects to improve cultivation in the Central Plain. J. Homan van de Heide, then head of the department, proposed that a dam be constructed across Chao Phya River at Chainat to divert water into the fields on both sides of the river to solve irrigation problems in the Central Plain, but it was not built at that time. Most of the projects entailed construction of gates and canals and rehabilitation of old canals for drainage. Such works included Pasak Project, Supanburi Project, and Chiengrag Klongdan. No major investment was made on construction of a diversion dam across a river until 1952 when the Chao Phya Dam was finally built. Since then, irrigation development has been emphasized in all National Development Plans.

Table 3 shows the expansion of the total irrigated area from the beginning to the present. During the first three National Development Plans, 1961-76, irrigated area increased by about 850,000 hectares. The rate of expansion has been slower than planned, for technical and administrative reasons. Moreover, the figures given are for areas considered irrigated in the wet season, but the actual area receiving a supply of irrigation water for dry-season cropping is much less -- only about 22 percent of the wet-season irrigated area in 1979.

Table 3--Irrigated area, selected years

| Year | Irrigated Area (hectares) |
|--------------------|------------------------------|
| 1910 | 48,000 |
| 1925 | 156,800 |
| 1931 | 400,000 |
| 1947 | 608,000 |
| 1957 ^{a/} | 1,296,000 |
| 1966 ^{a/} | 1,872,000 |
| 1971 ^{a/} | 2,128,054 |
| 1976 ^{a/} | 2,447,805 |
| 1979 | 2,555,877 |

Source: Sukitti Krajangyao, Irrigation in Thailand, Bangkok Bank Bulletin (Bangkok: Bangkok Bank Ltd., January-June 1978).

Note: Irrigated area includes that part of irrigable area where construction work has been completed.

^{a/}The First National Development Plan ended in 1966, the second ended in 1971, and the third ended in 1976.

3. STATUS AND PERFORMANCE OF IRRIGATION UP TO 1979

AREA

According to the definitions of the Royal Irrigation Department, a project area (command area) consists of irrigable and unirrigable areas. The latter includes the areas used for houses, shops, and roads, as well as swamp and forest areas. After these areas are deducted from the total project area, irrigable area remains. The irrigated area is then defined as the proportion of the irrigable area where construction work has been completed. However, in any one year the area actually irrigated depends on how much water is available.

By the end of 1978, 2.56 million hectares were reported to be irrigated in the sense that construction work was completed and the area was ready to receive irrigation water.^{2/} This accounts for 81.79 percent of the total project area. However, only 79.55 percent of the irrigated area was planted with rice in the wet season of 1978/79, and only 22.10 percent was planted with rice in the dry season of 1979 (see Tables 4 and 5).

The discrepancy between area irrigated and area planted during the wet season could imply that some of the minor water distribution systems were still incomplete, keeping the area from reaping the full benefit of irrigation. In the dry season, on the other hand, the discrepancy suggests that not enough water was available to cultivate the entire irrigated area. Thus the proportion of the irrigated area cultivated in the dry season could be used as an indicator of how much water is made available by the irrigation system. Area planted in the wet season cannot be used to indicate actual irrigated area because wet-season rice can be grown in unirrigated areas.

Another indicator of the extent of irrigation is the ratio of the irrigated area planted with rice to the total area planted in each season (see Table 5). For the wet season of 1978/79, this ratio was only 22 percent, suggesting that about 78 percent of the area planted in the wet season was rainfed. In the dry season of 1979, however, the ratio was 82.91 percent, which means that little dry-season cropping can be done outside the project areas.

^{2/}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 4--Irrigated area and area planted with rice, wet season 1978/79 and dry season 1979

| Type of Area | North | | Northeast | | Central Region | | South | | Whole Kingdom | |
|--|-----------------------------|---------------------|-----------------------------|---------------------|-----------------------------|---------------------|-----------------------------|---------------------|-----------------------------|---------------------|
| | Area (1,000 hectares) | Percent of Total | Area (1,000 hectares) | Percent of Total | Area (1,000 hectares) | Percent of Total | Area (1,000 hectares) | Percent of Total | Area (1,000 hectares) | Percent of Total |
| Irrigation project area 1978/79 | 328.10 | 10.48 | 425.05 | 13.57 | 2,168.42 | 69.23 | 210.63 | 6.72 | 3,132.20 | 100 |
| Irrigated area 1978/79 | 266.84 | 10.44 | 255.12 | 9.98 | 1,854.70 | 72.57 | 179.22 | 7.01 | 2,555.88 | 100 |
| Wet season 1978/79 | | | | | | | | | | |
| Rice planted area | 1,915.98 | 20.80 | 4,451.24 | 48.33 | 2,209.64 | 23.99 | 633.46 | 6.88 | 9,210.32 | 100 |
| Irrigated rice- planted area | 250.59 | 12.33 | 246.92 | 12.14 | 1,386.89 | 68.21 | 148.72 | 7.31 | 2,033.12 | 100 |
| Dry season 1979 | | | | | | | | | | |
| Rice-planted area | 91.84 | 13.48 | 25.44 | 3.73 | 554.24 | 81.35 | 9.76 | 1.43 | 681.28 | 100 |
| Rice-planted area under state irrigation | 19.70 | 3.49 | 13.97 | 2.47 | 525.88 | 93.10 | 5.30 | 0.94 | 564.85 | 100 |

Sources: 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); Thailand, Ministry of Agriculture and Cooperatives, Royal Irrigation Department, "Report on Dry Season Rice Production within Irrigation Project Areas, 1975-1979," Bangkok, 1975-79 (mimeographed, in Thai); Thailand, Ministry of Agriculture and Cooperatives, Office of Agricultural Economics, Agricultural Statistics of Thailand, Crop Year 1979/80 (Bangkok: Ministry of Agriculture and Cooperatives, 1980).

Note: For wet season 1978/79, the unirrigated rice-planted area is 7.18 million hectares; the unirrigated unplanted area is 1.98 million hectares; and the irrigated unplanted area is 0.53 million hectares. For dry season 1979, the unirrigated rice-planted area is 0.12 million hectares; the unirrigated unplanted area is 9.04 million hectares; and the irrigated unplanted area is 2.0 million hectares.

Table 5--Ratios for irrigated area and area planted with rice, wet season 1978/79 and dry season 1979

| Ratio | North | Northeast | Central Region (percent) | South | Whole Kingdom |
|--|-------|-----------|--------------------------------|-------|---------------|
| Wet Season 1978/79 | | | | | |
| Irrigated area 1978/79 /rice-planted area | 13.93 | 5.73 | 83.94 | 28.29 | 27.75 |
| Irrigated rice-planted area/rice-planted area | 13.08 | 5.55 | 62.77 | 23.48 | 22.07 |
| Irrigated rice-planted area/ irrigated area 1978/79 | 93.91 | 96.79 | 74.78 | 82.98 | 79.55 |
| Dry season 1979 | | | | | |
| Rice-planted area/ irrigated area 1978/79 | 34.42 | 9.97 | 29.88 | 5.45 | 26.66 |
| Rice-planted area under state irrigation/ rice-planted area | 21.45 | 54.91 | 94.88 | 54.30 | 82.91 |
| Rice-planted area under state irrigation/ irrigated area 1978/79 | 7.38 | 5.48 | 28.35 | 2.96 | 22.10 |

Sources: 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); Thailand, Ministry of Agriculture and Cooperatives, Royal Irrigation Department, "Report on Dry Season Rice Production within Irrigation Project Areas, 1975-1979," Bangkok, 1975-79 (mimeographed, in Thai); Thailand, Ministry of Agriculture and Cooperatives, Office of Agricultural Economics, Agricultural Statistics of Thailand, Crop Year 1979/80 (Bangkok: Ministry of Agriculture and Cooperatives, 1980).

STATE IRRIGATION PROJECTS

Surface water or gravity flow irrigation projects are constructed or contracted out by the Royal Irrigation Department. They consist of projects for a variety of purposes such as storing water (S), irrigation (I), flood control (F), drainage (D), hydroelectric power generation (H), conservation of water in the plains (C), pumping (P), land reclamation (R), or several of these. Irrigation projects make up 30.09 percent of this work, irrigation and drainage projects (ID) make up 30.08 percent, and irrigation and water conservation projects (IC) another 15.20 percent (see Table 6).

For this paper, however, irrigation will be classified into four categories (Table 7).

A category 1 project includes a complete irrigation system with land consolidation.^{3/} 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. The types of irrigation work forming the basis for land consolidation have been mostly ID. The area under this category amounted to only 32,303 hectares, or about 1.26 percent of the total irrigated area, at the end of 1978.

A category 2 project has a complete irrigation system with ditches and dikes. The only difference between this category and the first is the absence of land consolidation. Without it, the rice field 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 1,240,582 hectares or 48.54 percent of the total irrigated area. The basic types of irrigation projects under category 2 are I, SI, SiFD, and ID.

Although a category 3 project includes a complete irrigation 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, hardly any water is supplied for dry-season cropping, because most farms have no water control system. The total area under this category at the end of 1978 was 865,248 hectares or 33.85 percent of the total irrigated area. The major types of irrigation projects involved are I, SI, ID, ICD, and CF.

^{3/}According to the Royal Irrigation Department, land consolidation is the development of farm land with the emphasis on water control. It includes the construction of minor irrigation and drainage systems and farm roads, leveling of land, and realignment to reduce fragmentation.

Table 6--Irrigated area by region and type of irrigation project, 1979

| Type of Project | North | | | Northeast | | |
|--|--------------------|--|---|--------------------|--|---|
| | Area (hectares) | Percent of Area of all Projects in Region | Percent of Project Area in Whole Kingdom | Area (hectares) | Percent of Area of all Projects in Region | Percent of Project Area in Whole Kingdom |
| Projects including storage and irrigation | 14,699 | 2.94 | 7.52 | 161,520 | 48.47 | 82.60 |
| Projects including flood control | 47,280 | 9.45 | 18.38 | 46,880 | 14.07 | 18.22 |
| Projects including irrigation and water conservation in the plains | 15,216 | 3.04 | 3.47 | --- | --- | --- |
| Projects including irrigation and pumping | --- | --- | --- | --- | --- | --- |
| Projects including water conservation in the plains and drainage | 160 | 0.03 | 0.36 | --- | --- | --- |
| Projects including pumping | 19,032 | 3.80 | 22.15 | 17,440 | 5.23 | 20.30 |
| Irrigation projects | 352,322 | 70.42 | 40.60 | 75,107 | 22.54 | 8.66 |
| Projects to conserve water on the plains | 46,960 | 9.39 | 51.71 | 4,769 | 1.43 | 5.25 |
| Irrigation and drainage projects | 4,640 | 0.93 | 0.53 | 27,488 | 8.25 | 3.17 |
| Total | 500,309 | 100 | 17.35 | 333,204 | 100 | 11.56 |

Table 6, continued--Irrigated area by region and type of irrigation project, 1979

| Type of Project | Central Region | | | South | | | Whole Kingdom | | |
|--|----------------|--|---|------------|--|---|---------------|--|---|
| | Area | Percent of Area of all Projects in Region | Percent of Project Area in Whole Kingdom | Area | Percent of Area of all Projects in Region | Percent of Project Area in Whole Kingdom | Area | Percent of Area of all Projects in Region | Percent of Project Area in Whole Kingdom |
| | (hectares) | | | (hectares) | | | (hectares) | | |
| Projects including storage and irrigation | 19,317 | 1.07 | 9.88 | --- | --- | --- | 195,536 | 6.78 | 100 |
| Projects including flood control | 91,520 | 5.06 | 35.57 | 71,600 | 29.70 | 27.83 | 257,280 | 8.92 | 100 |
| Projects including irrigation and water conservation in the plains | 423,200 | 23.40 | 96.53 | --- | --- | --- | 438,416 | 15.20 | 100 |
| Projects including irrigation and pumping | 33,056 | 1.83 | 100 | --- | --- | --- | 33,056 | 1.15 | 100 |
| Projects including water conservation in the plains and drainage | 8,480 | 0.47 | 14.62 | 19,360 | 20.47 | 85.10 | 58,000 | 2.01 | 100 |
| Projects including pumping | 28,316 | 1.57 | 32.96 | 10,560 | 4.38 | 12.29 | 85,908 | 2.98 | 100 |
| Irrigation projects | 338,493 | 18.71 | 39.01 | 101,774 | 42.21 | 11.73 | 867,696 | 30.09 | 100 |
| Projects to conserve water on the plains | 31,264 | 1.73 | 34.43 | 7,824 | 3.25 | 8.62 | 90,817 | 3.15 | 100 |
| Irrigation and drainage projects | 835,184 | 46.17 | 96.30 | --- | --- | --- | 867,312 | 30.08 | 100 |
| Total | 1,808,830 | 100 | 62.73 | 241,118 | 100 | 8.36 | 2,883,461 | 100 | 100 |

Source: Thailand, Ministry of Agriculture and Cooperatives, Royal Irrigation Department, Table Showing Water Resources Development in Thailand, Completed to the End of 1979 and under Construction in 1980 (Bangkok: Ministry of Agriculture and Cooperatives, 1980).

Table 7--Irrigated area by category and region, 1978/79

| Category | North | | | Northeast | | |
|------------|-----------------------------|---|---|-----------------------------|---|---|
| | Area (1,000 hectares) | Percent of all Area under Category | Percent of Area in Whole Kingdom | Area (1,000 hectares) | Percent of all Area under Category | Percent of Area in Whole Kingdom |
| Category 1 | --- | --- | --- | 2.50 | 0.98 | 7.73 |
| Category 2 | 129.56 | 48.55 | 10.44 | 72.10 | 28.26 | 5.81 |
| Category 3 | 62.83 | 23.55 | 7.26 | 106.89 | 41.90 | 12.35 |
| Category 4 | 74.45 | 27.90 | 17.82 | 73.63 | 28.86 | 17.63 |
| Total | 266.84 | 100 | 10.44 | 255.12 | 100 | 9.98 |

Table 7, continued--Irrigated area by category and region, 1978/79

| Category | Area (1,000 hectares) | Central Region | | Area (1,000 hectares) | South | | Area (1,000 hectares) | Whole Kingdom | |
|------------|-----------------------------|---|---|-----------------------------|---|---|-----------------------------|---|---|
| | | Percent of all Area under Category | Percent of Area in Whole Kingdom | | Percent of all Area under Category | Percent of Area in Whole Kingdom | | Percent of all Area under Category | Percent of Area in Whole Kingdom |
| Category 1 | 29.80 | 1.61 | 92.27 | --- | --- | --- | 32.30 | 1.26 | 100 |
| Category 2 | 1,018.16 | 54.90 | 82.07 | 20.76 | 11.58 | 1.67 | 1,240.58 | 48.54 | 100 |
| Category 3 | 593.58 | 32.00 | 68.60 | 101.95 | 56.89 | 11.78 | 865.25 | 33.85 | 100 |
| Category 4 | 213.15 | 11.49 | 51.02 | 56.51 | 31.53 | 13.53 | 417.74 | 16.34 | 100 |
| Total | 1,854.70 | 100 | 72.57 | 179.22 | 100 | 7.01 | 2,555.88 | 100 | 100 |

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).

Notes: 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.

Under category 4, some of the irrigation system has been constructed but is not complete. The area under this category totalled 417,744 hectares, or 16.34 percent of the total irrigated area at the end of 1978. The types of irrigation projects constructed include SI, FC, ID, and I.

It should be noted that an area can be included in more than one category simultaneously. For example, an irrigation project of the ID or SIFD type may have a portion of its area under category 1 (land consolidation has been implemented), another portion under category 2 (with ditches and dikes), and a third portion under category 3 (neither land consolidation nor ditches and dikes have been started). Such projects are Nam-pong (ID) and Nam-ocn (SIFD) in the Northeast and Samchook (ID) in the Central Region.^{4/} Similarly, a number of projects in the Central may be under categories 2 and 3 or 2, 3, and 4 simultaneously.

Groundwater has been used for irrigation in a number of provinces in the North and Northeast only recently. In the North, it was first used in 1976 on dry-season crops such as peanuts, maize, tobacco, watermelons, soybeans, mungbeans, and garlic. A study by the Division of Agricultural Economics has shown an internal rate of return of 35 percent for the Lampoon Groundwater Project.^{5/} Such a project, however, requires a large capital investment as well as specialized technical knowledge and equipment; hence, government participation in the whole project is required. Farmers can provide pumps, construct canals and pipes, and contribute operation and maintenance costs if the necessary credit is available.

The plan for development of the Yom Basin in the North calls for groundwater irrigation in the Sukothai area in the initial stage before the construction of a storage and a diversion dam. Tubewells can be constructed in a relatively short period of time and benefits are derived immediately after completion. The Sukothai Groundwater Project consists of 204 tubewells. Only the 100 wells in the project's second zone were completed in 1982; they were beginning to provide water to about 4,800 hectares for the dry-season crop. In its first zone, 35 of the 104 tubewells should be completed by the end of 1982.

^{4/}Sometimes the Office of Agricultural Economics divides the whole kingdom into four regions, sometimes six. The North, Northeast, and South are the same in both cases, but under six regions, the Central Region is subdivided into the Central Plain, the West, and the East. Central Region as used in this paper includes the Central Plain, the West, and the East.

^{5/}Ministry of Agriculture and Cooperatives, Division of Agricultural Economics, Returns and Repayment of Investment Cost for Groundwater Project for Agriculture in Lampoon, Farm Management Paper No. 28 (Bangkok: Ministry of Agriculture and Cooperatives, 1978).

PEOPLE'S IRRIGATION PROJECTS

Small projects, such as weirs, canal rehabilitation, drainage structures, pumps, and tanks that require small budgets and unsophisticated technology for construction are people's irrigation projects. The construction, operation, and maintenance of these projects were undertaken by local people for the benefit of particular districts, mostly in the upper part of the North.

Since 1960, the Department of Local Administration in the Ministry of Interior has allocated funds to provinces for these small projects, with priority going to those areas with the most severe water shortages. Projects where local people have contributed money, labor, and materials toward their construction, though the money was inadequate, have also received priority. The Ministry of Interior, instead of the Royal Irrigation Department, became responsible for these projects because the Ministry of Interior has a hierarchy of officials extending from the village to the provincial level. These officials are expected to be familiar with the living conditions and needs of the people in the district. However, the allocated budget is quite small and is not sufficient to solve all the problems concerning water shortage. The 1978 budget for people's projects throughout the Kingdom was only 20 million baht.^{6/}

Table 8 shows the number of projects and the cost of their construction by region in 1978. Table 9 shows the budgets allocated to people's projects since 1961. Unfortunately, data on the area covered by these projects are not available. A rough estimate, however, can be made from the difference between actual planted area and irrigated area. Because the former far exceeds the latter, part of the difference can be explained by people's projects. On the other hand, counting these areas may be redundant because people's projects are often constructed in areas already under large project development but where actual irrigated area is confined to the vicinity of the main distribution system.

Because people's projects are concentrated in the northern region, the only available figure for the area covered by these projects is that for the North in 1970, which is 276,800 hectares or about 47 percent of wet-season irrigated area in the region.

^{6/}In 1978, U.S. \$1 equaled 20 baht.

Table 8--Budget for people's irrigation projects, by region, 1978

| Region | Number of Projects | Cost of Construction to the Department of Local Administration (million baht) |
|----------------|--------------------------|--|
| North | 53 | 5.05 |
| Northeast | 54 | 5.95 |
| Central Region | 46 | 5.06 |
| South | 39 | 3.25 |
| Total | 192 | 19.32 |

Source: Thailand, Ministry of Interior, Department of Local Administration, unpublished data.

Table 9--Budget for people's irrigation projects in the budget of the Department of Local Administration, 1961-79

| Year | Budget Received (million baht) |
|--------------------|-----------------------------------|
| 1961 | 5.0 |
| 1962 | 6.0 |
| 1963 | 6.0 |
| 1964 | 6.2 |
| 1965 | 18.0 |
| 1966 | 8.0 |
| 1967 | 12.0 |
| 1968 | 15.0 |
| 1969 | 15.0 |
| 1970 | 15.0 |
| 1971 | 21.9 |
| 1972 | 25.0 |
| 1973 | 10.0 |
| 1974 | 20.2 |
| 1975 | 15.0 |
| 1976 | 65.7 |
| 1977 | --- ^{a/} |
| 1978 ^{b/} | 20.0 |
| 1979 ^{b/} | 10.0 |

Source: Thailand, Ministry of Interior, Department of Local Administration, unpublished data.

^{a/}This figure was confused with the Royal Irrigation Department budget.

^{b/}The proposed budget was 65 million baht.

4. REGIONAL DISTRIBUTION OF IRRIGATED AREA AND TYPES OF IRRIGATION

AREA

Irrigated area is not equally distributed among regions. Table 4 shows that of the total irrigated area of 2.56 million hectares in 1979, 72.57 percent was in the Central Region. The North and North-east had about 10 percent each and the South only about 7 percent. Table 5 shows that the percentage of wet-season rice that is irrigated is the highest in the Central Region and lowest in the Northeast. In the Central Region it is about 63 percent, in the North about 13 percent, in the Northeast about 6 percent, and in the South about 23 percent.

As mentioned, rice will only grow in the irrigated area during the dry season. The ratio of the area planted with rice in the dry season to irrigated area is highest in the North (34.42 percent) and the Central Region (29.88 percent), and lowest in the South (5.45 percent). The percentage for the North may be high because a large part of the rice area in this region is irrigated by people's irrigation projects, even in the dry season. Taking these into account, the distribution of the actual irrigated area may be less concentrated in the Central Plain than the official figures indicate.

State irrigation facilities are concentrated on the Central Plain because the plain is the most important rice producing area in the country. The surplus rice available for exports comes from this region. Therefore, the government has tried to promote increased production by expanding productivity and land-use intensity in the Central Plain through the use of new inputs, such as fertilizer and high-yielding varieties.

To achieve these targets, it was necessary to make a larger investment in irrigation in this region for the construction of ditches and dikes and for land consolidation. Hence, in the past two decades irrigation investment has been more intensive in the Central Plain than in the other regions.

TYPES OF IRRIGATION WORK

The variation in the types of irrigation work among regions depends on geographical and soil conditions. In addition to diversion irrigation (I), which covers a significant percentage of the irrigated area in all regions, most projects are also designed to serve specific purposes. These are, for example, storage of water (S) in the

Northeast, where the soil has a low absorptive capacity for water; conservation (C) and drainage (D) in the Central Plain, where the land is flat; and flood control (F) in the South, where rainfall is heavy. Pumping (P), on the other hand, is distributed more equally, with about one third of the area benefited located in the Central Plain.

As a result, types I and C are concentrated in the North and in the Central Plain, SI in the Northeast, ID and ICD in the Central Plain, and CD and CDF in the South. See Tables 10-13 for a detailed account of irrigated area in each region by river basin and type of irrigation work.

It is more meaningful, perhaps, to look at the distribution of irrigated area by category of irrigation as defined earlier. Table 7 shows that the Central Region accounts for the largest percentage of area in each category, with the percentage increasing as the irrigation system becomes more complete; that is, 51 percent in category 4, 69 percent in category 3, 82 percent in category 2, and 92 percent in category 1.

This suggests that the Central Region not only has the most irrigated area but also has the irrigation that best controls water on farms.

Table 10--Irrigated area in the North by type of irrigation project, 1978

| River Basin | SIFH, SIF, SI | I | F | C, CD | P | D | IC | FC | Total |
|--|---------------------|---------|-------|-------------------|-------|-------|--------|--------|---------|
| | (hectares) | | | | | | | | |
| Salween | 1,600 | 2,680 | --- | --- | --- | --- | --- | --- | 4,280 |
| Ping | 1,661 ^{a/} | 192,355 | 1,200 | 5,440 | --- | --- | --- | --- | 200,656 |
| Mae Khong | 144 | 32,986 | --- | --- | --- | --- | --- | --- | 33,130 |
| Mae Wang | 7,256 | 15,632 | --- | 160 ^{b/} | --- | --- | --- | --- | 23,048 |
| Mae Yom | --- | 40,640 | --- | 6,176 | 1,746 | 9,600 | --- | 640 | 58,802 |
| Nan | 304 ^{a/} | 44,587 | --- | 22,320 | --- | --- | 15,216 | 45,440 | 127,867 |
| Sakae Krang (Nakornsawan- Uthaitani) | --- | 21,984 | --- | 1,600 | --- | --- | --- | --- | 23,584 |
| Upper Pasak | 2,176 | 5,440 | --- | --- | --- | --- | --- | --- | 7,616 |
| Total | 13,141 | 356,304 | 1,200 | 35,696 | 1,746 | 9,600 | 15,216 | 46,080 | 478,983 |

Source: Thailand, Ministry of Agriculture and Cooperatives, Royal Irrigation Department, Table Showing Water Resources Development in Thailand, Completed to the End of 1978 and under Construction in 1979 (Bangkok: Ministry of Agriculture and Cooperatives, 1979).

Notes: C = conservation of water in the plains; D = drainage; F = flood control; H = hydro-electric power generation; I = irrigation; P = pumping; S = storage of water.

^{a/}There are 320,000 hectares in the Ping River Basin and 400,000 hectares in the Nan River Basin for a total of 720,000 hectares, which are in the Chao Phya Project, but water delivery systems from Bhumibol and Sirikit Dams do not exist, so these areas are not included in the whole basin area.

^{b/}This includes only conservation and drainage projects.

Table 11--Irrigated area in the Northeast by type of irrigation project, 1978

| River Basin | SIFH, SIF, SI | I | C | FC | ID | P | PD | Total |
|-------------|---------------|--------|-------|--------|--------|-------|--------|---------|
| | (hectares) | | | | | | | |
| Mae Khong | 54,459 | 9,257 | 525 | 10,240 | --- | 2,880 | --- | 77,361 |
| Chi | 48,446 | 4,455 | 2,240 | 36,640 | 34,534 | --- | --- | 126,315 |
| Mun | 63,421 | 44,515 | 1,010 | --- | --- | --- | 17,105 | 126,051 |
| Pasak | 480 | --- | --- | --- | --- | --- | --- | 480 |
| Total | 166,806 | 58,227 | 3,775 | 46,880 | 34,534 | 2,880 | 17,105 | 330,207 |

Source: Thailand, Ministry of Agriculture and Cooperatives, Royal Irrigation Department, Table Showing Water Resources Development in Thailand, Completed to the End of 1978 and under Construction in 1979 (Bangkok: Ministry of Agriculture and Cooperatives, 1979).

Notes: C = conservation of water in the plains; D = drainage; F = flood control; H = hydroelectric power generation; I = irrigation; P = pumping; S = storage of water.

Table 12--Irrigated area in the Central Plain by type of irrigation project, 1978

| River Basin | SIFD, SIFH, SIF, SI | I | C | CD, CDF | ID (hectares) | ICD | P, PD | IPD | ICRD | F, FC | Total |
|-------------------------|------------------------|---------------------|--------|---------------------|------------------|---------|----------------------|--------|---------|---|-----------|
| Chao Phya | 17,865 | 16,496 | 800 | --- | 689,584 | 257,600 | 22,672 ^{a/} | 30,720 | 165,600 | --- | 1,201,337 |
| West Bank | 14,385 ^{b/} | 3,120 ^{b/} | --- | --- | 367,840 | 209,600 | 14,752 ^{a/} | --- | --- | --- | 609,697 |
| East Bank | 3,480 | 13,376 | 800 | --- | 321,744 | 48,000 | 7,920 ^{a/} | 30,720 | 84,000 | --- | 510,040 |
| Chiangrak-Khlong Dan | --- | --- | --- | --- | --- | --- | --- | --- | 81,600 | --- | 81,600 |
| Bank Pakong | --- | 25,360 | 2,352 | 6,560 ^{c/} | 91,840 | --- | --- | --- | --- | 71,680 ^{d/} | 197,792 |
| East Coast Basin | 1,360 | 7,360 | 480 | 320 ^{e/} | --- | --- | --- | --- | --- | 13,040 ^{d/} 3,680 ^{f/} | 26,240 |
| Khmer Lake Basin | --- | 720 | 3,040 | --- | --- | --- | --- | --- | --- | --- | 3,760 |
| Mae Klong | --- | 249,592 | 20,800 | --- | --- | --- | 1,360 ^{g/} | --- | --- | --- | 271,752 |
| Greater Mae Klong | --- | 248,680 | --- | --- | --- | --- | --- | --- | --- | --- | 248,680 |
| Vajiralongkorn Dam | --- | 912 | 20,800 | --- | --- | --- | 1,360 ^{g/} | --- | --- | --- | 23,072 |
| Other | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Phetchaburi | 413 | 413 | --- | --- | 53,760 | --- | 80 ^{g/} | --- | --- | --- | 54,666 |
| Total | 19,638 | 299,941 | 27,472 | 6,880 | 835,184 | 257,600 | 24,112 | 30,720 | 165,600 | 88,400 | 1,755,547 |

Source: Thailand, Ministry of Agriculture and Cooperatives, Royal Irrigation Department, Table Showing Water Resources Development in Thailand, Completed to the End of 1978 and under Construction in 1979 (Bangkok: Ministry of Agriculture and Cooperatives, 1979).

Notes: C = conservation of water in the plains; D = drainage; F = flood control; H = hydroelectric power generation; I = irrigation; P = pumping; R = land reclamation; S = storage of water.

^{a/}This includes only pumping and drainage projects.

^{b/}This area is outside the Greater Chao Phya Project.

^{c/}This includes only conservation and drainage projects.

^{d/}This includes only flood control and conservation projects.

^{e/}This includes only conservation, drainage, and flood control projects.

^{f/}This includes only flood control projects.

^{g/}This includes only pumping projects.

Table 13--Irrigated area in the South by type of irrigation project, 1978

| River Basin | SIFR, SIFH, SIF, SI | I | C | F | CDF (hectares) | CD | CF | P | ID | Total |
|--------------------------|------------------------|--------|-----|--------|-------------------|--------|--------|-------|--------|---------|
| Pranburi | 20,222 | --- | 32 | --- | --- | --- | --- | --- | --- | 20,254 |
| East Coast ^{a/} | --- | 21,968 | --- | 4,800 | 480 | 21,440 | 3,200 | --- | --- | 51,888 |
| Tapi-Pumduang | --- | 5,920 | --- | 1,120 | --- | 4,000 | --- | --- | --- | 11,040 |
| Pak Phanang | --- | 1,680 | --- | 6,400 | --- | 2,080 | 34,480 | --- | --- | 44,640 |
| Songkhla Lake | --- | 52,080 | 800 | --- | --- | --- | 5,920 | 9,600 | --- | 68,400 |
| Pattani | --- | --- | --- | --- | --- | --- | --- | --- | 19,032 | 19,032 |
| Bang Nara-Kolok | --- | --- | --- | --- | 10,101 | 480 | 1,600 | --- | --- | 12,181 |
| Total | | 81,648 | 800 | 12,320 | 10,581 | 28,000 | 45,200 | 9,600 | 19,032 | 207,181 |
| West Coast ^{a/} | --- | 9,792 | --- | --- | 480 | --- | --- | --- | --- | 10,272 |
| Trang | --- | 4,528 | --- | --- | --- | --- | 1,200 | --- | --- | 5,728 |
| Total | | 14,320 | | | 480 | | 1,200 | | | 16,000 |
| Total | 20,222 | 95,968 | 832 | 12,320 | 11,061 | 28,000 | 46,400 | 9,600 | 19,032 | 243,435 |

Source: Thailand, Ministry of Agriculture and Cooperatives, Royal Irrigation Department, Table Showing Water Resources Development in Thailand, Completed to the End of 1978 and under Construction in 1979 (Bangkok: Ministry of Agriculture and Cooperatives, 1979).

Notes: C = conservation of water in the plains; D = drainage; F = flood control; H = hydroelectric power generation; I = irrigation; P = pumping; R = land reclamation; S = storage of water.

^{a/}The East and West Coasts have their own irrigated areas.

5. RICE YIELDS

Table 14 clearly shows that wet-season rice yields are higher in irrigated areas than in rainfed areas. Before 1968/69 rainfed yields were about 40 percent of irrigated yields, but the gap between the two has decreased since then. Yields from rainfed areas increased from about 1.07 metric tons per hectare during 1958/59-1968/69 to about 1.47 tons per hectare during 1969/70-1978/79, but yields from irrigated areas only increased from an average of 2.46 tons per hectare to 2.62 tons per hectare during the same period.^{7/} In fact, they remained at about 2.55 tons per hectare until 1975/76; after that they increased to 2.79 tons per hectare.

Irrigation apparently brought about a sharp increase in the wet-season yield when it was introduced, but this increase did not persist. One factor may be the poor maintenance of irrigation facilities, which decreases the effectiveness of the irrigation system. Another plausible explanation is that the increased adoption of high-yielding varieties in irrigated areas has not been accompanied by a sufficient increase in fertilizer application. This is mainly because fertilizer prices have been high relative to the price of paddy.

Thus, although the proportion of irrigated area planted in the wet season to the total planted area remained constant, the relatively slow growth of yields in irrigated areas caused the share of output from irrigated area in total output to decline from more than 40 percent before 1968/69 to about 35 percent between 1969/70 and 1978/79.

Unless yields from irrigated areas can expand more rapidly and the proportion of planted area under irrigation can increase relative to rainfed planted area, it is not likely that wet-season rice production will increase significantly.

Large differences between the yields of irrigated and unirrigated areas are also found for the dry season. During the period 1975-79, yields from unirrigated areas were less than half of yields in irrigated areas (see Table 15). Moreover, the proportion of planted area under irrigation to total planted area shows an increasing trend from 75 percent in 1975 to 88 percent in 1979. Thus, there is hope that the total dry-season planted area will continue to grow and that the proportion of the planted area under irrigation will continue to increase, thereby increasing the dry-season rice output.

^{7/}All tons are metric tons.

Table 14--Comparison of rice yields in irrigated and unirrigated areas, wet season 1958/59-1978/79

| Year | Whole Kingdom | | Project Area | | Outside Project Area | | Ratio of Planted Project Area to Whole Kingdom (percent) | Ratio of Yields Outside Project Area to Project Area |
|---------|---------------------|------------------------------|---------------------|------------------------------|----------------------|------------------------------|---|--|
| | Planted Area | Yield | Planted Area | Yield | Planted Area | Yield | | |
| | (1,000 hectares) | (metric tons/ hectare) | (1,000 hectares) | (metric tons/ hectare) | (1,000 hectares) | (metric tons/ hectare) | | |
| 1958/59 | 5,758 | 1.21 | 1,363 | 2.23 | 4,395 | 0.90 | 23.67 | 40.36 |
| 1959/60 | 6,066 | 1.10 | 1,318 | 2.16 | 4,747 | 0.81 | 21.74 | 37.50 |
| 1960/61 | 5,922 | 1.31 | 1,370 | 2.57 | 4,552 | 0.93 | 23.13 | 36.19 |
| 1961/62 | 6,168 | 1.31 | 1,428 | 2.54 | 4,741 | 0.94 | 23.14 | 37.01 |
| 1962/63 | 6,648 | 1.39 | 1,629 | 2.54 | 5,019 | 1.02 | 24.50 | 40.16 |
| 1963/64 | 6,602 | 1.52 | 1,678 | 2.58 | 4,923 | 1.58 | 25.42 | 61.24 |
| 1964/65 | 6,539 | 1.46 | 1,762 | 2.29 | 4,778 | 1.16 | 26.94 | 50.66 |
| 1965/66 | 6,554 | 1.40 | 1,754 | 2.48 | 4,800 | 1.01 | 26.76 | 40.73 |
| 1966/67 | 7,432 | 1.61 | 1,768 | 2.52 | 5,664 | 1.32 | 23.79 | 52.38 |
| 1967/68 | 6,658 | 1.45 | 1,763 | 2.60 | 4,894 | 1.03 | 26.48 | 39.62 |
| 1968/69 | 7,227 | 1.43 | 1,768 | 2.52 | 5,459 | 1.08 | 24.46 | 42.86 |
| 1969/70 | 7,637 | 1.75 | 1,802 | 2.39 | 5,835 | 1.55 | 23.59 | 64.85 |
| 1970/71 | 7,802 | 1.72 | 1,838 | 2.42 | 5,963 | 1.50 | 23.56 | 61.98 |
| 1971/72 | 8,003 | 1.77 | 1,872 | 2.68 | 6,131 | 1.50 | 23.39 | 55.97 |
| 1972/73 | 7,139 | 1.63 | 1,808 | 2.55 | 5,331 | 1.32 | 25.32 | 51.76 |
| 1973/74 | 7,611 | 1.83 | 1,822 | 2.75 | 5,789 | 1.54 | 23.94 | 56.00 |
| 1974/75 | 7,328 | 1.72 | 1,856 | 2.51 | 5,472 | 1.45 | 25.33 | 57.77 |
| 1975/76 | 8,411 | 1.87 | 1,882 | 2.52 | 6,530 | 1.69 | 22.37 | 67.00 |
| 1976/77 | 8,440 | 1.96 | 1,914 | 2.78 | 6,526 | 1.72 | 22.67 | 61.87 |
| 1977/78 | 8,398 | 1.46 | 1,941 | 2.82 | 6,458 | 1.05 | 23.11 | 37.23 |
| 1978/79 | 9,277 | 1.71 | 2,035 | 2.76 | 7,242 | 1.41 | 21.94 | 51.09 |

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 15--Comparison of rice yields in irrigated and unirrigated areas, dry season 1975-79

| Year | Planted Area Under Irrigation (hectares) | Irrigated Planted Area as Percentage of Total Planted Area | Unirrigated Planted Area (hectares) | Irrigated Yield (metric tons/hectare) | Unirrigated Yield |
|------|---|--|--|--|-------------------|
| 1975 | 305,750 | 74.56 | 104,334 | 4.11 | 1.22 |
| 1976 | 370,466 | 80.76 | 88,262 | 3.82 | 0.61 |
| 1977 | 408,073 | 83.21 | 82,311 | 3.83 | 2.95 |
| 1978 | 407,024 | 83.13 | 82,574 | 3.76 | 1.61 |
| 1979 | 564,850 | 87.74 | 78,921 | 3.59 | 1.37 |

Source: Thailand, Ministry of Agriculture and Cooperatives, Royal Irrigation Department, "Report on Dry Season Rice Production within Irrigation Project Areas, 1975-1979." Bangkok, 1979. (Mimeographed, in Thai.)

Among categories of irrigated area, there are also significant yield differences. For the wet season of 1978/79, the yield of area under category 1 was 3.21 tons per hectare, and it continued to decline to 2.95, 2.71, and 2.28 tons per hectare for area under categories 2, 3, and 4 respectively (see Table 16).

Yield differences also exist among regions, even for the areas under the same irrigation category. The North has the highest yield in each category as well as for all categories together. The Central Plain comes second, with the exception of category 4, where the South is second. The Northeast has the lowest yield for categories 3 and 4, whereas the South has the lowest yield in category 2.

Although the yield is highest under category 1, as might be expected, the irrigated area under this category constitutes only 1.26 percent of total area and production contributes only 1.41 percent of the total for all irrigated area. The largest percentage of irrigated area is in category 2 (48.54 percent) and category 3 (33.85 percent). The largest percentage of production also comes from category 2 (55.08 percent), followed by category 3 (28.92 percent).

It should also be noted that dry-season cropping is practiced mainly on the area under the first three categories, which totals 2.14 million hectares, 82.33 percent of which is in the Central Plain, 10.18 percent in the North, 5.86 percent in the Northeast, and only 1.63 percent in the South. Dry-season cropping on irrigated area in 1979, however, only covered 564,850 hectares, 53 percent of which was under categories 1 and 2. The total irrigated area under category 1

Table 16--Wet-season rice yields by category of irrigation, 1978/79

| Category | North | Northeast | Central Plain | South | Whole Kingdom |
|-----------------------------|---------|-----------|---------------|---------|---------------|
| Category 1 | | | | | |
| Planted area (hectares) | --- | 2,099 | 22,490 | --- | 24,589 |
| Production (metric tons) | --- | 1,160 | 77,856 | --- | 79,016 |
| Yield (metric tons/hectare) | --- | 0.55 | 3.46 | --- | 3.21 |
| Category 2 | | | | | |
| Planted area (hectares) | 118,999 | 89,360 | 821,256 | 20,160 | 1,049,775 |
| Production (metric tons) | 422,489 | 207,547 | 2,416,529 | 46,340 | 3,092,916 |
| Yield (metric tons/hectare) | 3.55 | 2.32 | 2.94 | 2.30 | 2.95 |
| Category 3 | | | | | |
| Planted area (hectares) | 58,742 | 84,958 | 374,062 | 81,491 | 599,253 |
| Production (metric tons) | 204,656 | 203,445 | 998,657 | 217,491 | 1,624,249 |
| Yield (metric tons/hectare) | 3.48 | 2.39 | 2.67 | 2.67 | 2.71 |
| Category 4 | | | | | |
| Planted area (hectares) | 72,846 | 70,401 | 169,082 | 47,072 | 359,401 |
| Production (metric tons) | 221,937 | 103,756 | 378,148 | 115,542 | 819,383 |
| Yield (metric tons/hectare) | 3.05 | 1.47 | 2.24 | 2.45 | 2.28 |
| Total | | | | | |
| Planted area (hectares) | 250,587 | 246,818 | 1,386,890 | 148,723 | 2,033,018 |
| Production (metric tons) | 849,062 | 515,908 | 3,871,200 | 379,373 | 5,615,563 |
| Yield (metric tons/hectare) | 3.39 | 2.09 | 2.79 | 2.55 | 2.76 |

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).

Notes: 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.

is entirely double cropped, whereas the double-cropped area under categories 2, 3, and 4 amounted to 21.49 percent, 29.71 percent, and 2.12 percent of the total area under each category.

If the additional yields that can be obtained by moving from one category to another are compared, one finds that moving from category 4 to 3 gives the largest additional yield -- 0.43 tons per hectare. Moving from category 3 to 2 yields an additional 0.24 tons per hectare, and moving from category 2 to 1 yields 0.26 tons per hectare. The highest additional yield would of course result from converting unirrigated land to irrigated in category 4. The yield increase is from 1.41 to 2.28 tons per hectare or 0.87 tons per hectare.

Therefore, to increase total rice production most effectively, an additional investment should be made first to irrigate rainfed areas, then to convert areas under categories 4 to 3, 2 to 1, and 3 to 2 in that order. In so planning, however, the additional investment costs for each irrigation improvement will have to be taken into consideration.

6. COSTS OF CONSTRUCTION, OPERATION, AND MAINTENANCE OF IRRIGATION PROJECTS

The total budget of the Royal Irrigation Department each year can be divided into four parts: general services, which includes general administration, engineering, machinery services, and pumping irrigation for crops; operation and maintenance, which includes operation and maintenance, canal rehabilitation, ditches and dikes construction, improvement of the water distribution system to increase yield, navigation locks, agricultural irrigation development works, drainage, and improvement of tanks and reservoirs; construction of large state projects; and construction of small people's projects.

The annual budgets in 1976 prices since 1961 are presented in Table 17. Although total budgets have increased over the years (except during the 1971-74 period and in 1979), the proportion of the budget allocated to large projects declined from 65 percent in 1961 to 39 percent in 1979, whereas the proportion allocated to small projects increased from 9 percent in 1961 to 23 percent in 1979. The relative change in the budget allocated for large and small projects confirms that there has been a change in irrigation development policies toward a more intensive, small-scale type of development.

COSTS OF LARGE PROJECTS

Projects classified as large are those costing more than 200 million baht per project. At present, there are 14 large projects under construction: four in the North, three in the Central Plain, five in the Northeast, and two in the South. The construction costs per hectare irrigated and per ton of rice output of these projects are given in Table 18. Large variations in these costs are observed, both among types of projects and among regions. However, it can be generally concluded that the cost per hectare would be comparable for the same types of projects with similar area coverage or storage capacity. For example, Nam Pong Project in the Northeast is similar in cost to Pattani Project in the South and Nam Un Dam in the Northeast is similar to Pranburi Dam in the South. Costs per hectare are almost the same for Huai Luang Dam in the Northeast and for the Mae Kuang Dam in the North. Both are SIF type projects, but the storage capacity, area coverage, and total cost of the former are proportionately lower than those of the latter.

On the other hand, costs per hectare can be different even for the same type of project in the same region if storage capacity and area coverage differ greatly, such as the Mae Ngat and Mae Kuang Dam projects in the North.

Table 17--Annual budget of the Royal Irrigation Department, 1961-79

| Year | Total Budget | General | Operation and Maintenance (million baht) | Construction | |
|------|-----------------|---------------------|---|---------------------|----------------------|
| | | | | State Projects | People's Projects |
| 1961 | 753.36 | 87.59 (11.62) | 104.31 (13.85) | 490.70 (65.13) | 70.77 (9.39) |
| 1962 | 1,026.96 | 132.59 (12.91) | 140.98 (13.73) | 634.62 (61.80) | 116.76 (11.37) |
| 1963 | 1,234.87 | 127.42 (10.32) | 182.11 (14.75) | 787.17 (63.75) | 138.16 (11.19) |
| 1964 | 1,088.26 | 148.57 (13.65) | 228.40 (20.99) | 625.80 (57.50) | 85.49 (7.86) |
| 1965 | 1,548.46 | 385.02 (24.86) | 287.31 (18.55) | 740.05 (46.79) | 136.09 (8.79) |
| 1966 | 1,655.13 | 312.01 (18.85) | 290.99 (17.58) | 901.09 (54.44) | 151.03 (9.12) |
| 1967 | 2,166.48 | 313.46 (14.47) | 374.80 (17.30) | 1,278.17 (59.00) | 200.05 (9.23) |
| 1968 | 2,638.53 | 325.05 (12.32) | 457.60 (17.34) | 1,490.24 (56.48) | 365.65 (13.86) |
| 1969 | 2,950.28 | 392.65 (13.31) | 504.50 (17.10) | 1,595.42 (54.08) | 457.21 (15.50) |
| 1970 | 3,837.80 | 927.27 (24.16) | 627.54 (16.35) | 1,541.47 (40.17) | 741.49 (19.32) |
| 1971 | 3,632.42 | 1,162.68 (32.01) | 349.53 (9.62) | 1,411.36 (38.85) | 708.84 (19.51) |
| 1972 | 2,980.81 | 1,008.52 (33.83) | 330.45 (11.09) | 1,070.12 (35.90) | 571.72 (19.18) |
| 1973 | 1,936.92 | 795.06 (41.05) | 258.85 (13.36) | 546.78 (28.23) | 336.23 (17.36) |
| 1974 | 1,827.32 | 708.63 (38.78) | 219.73 (12.02) | 603.22 (33.01) | 295.72 (16.18) |
| 1975 | 2,588.60 | 885.07 (34.19) | 350.21 (13.53) | 912.13 (35.24) | 441.21 (17.04) |
| 1976 | 2,604.92 | 540.40 (20.75) | 537.39 (20.63) | 936.43 (35.95) | 590.70 (22.68) |
| 1977 | 3,212.59 | 1,120.08 (34.87) | 562.25 (17.50) | 863.78 (26.89) | 666.49 (20.75) |
| 1978 | 3,496.18 | 1,015.56 (29.05) | 690.84 (19.76) | 1,094.40 (31.30) | 695.63 (19.90) |
| 1979 | 2,531.37 | 295.13 (11.66) | 655.25 (25.89) | 998.41 (39.44) | 582.58 (23.01) |

Sources: Thailand, Ministry of Agriculture and Cooperatives, Royal Irrigation Department, Expenditure Account, various issues (Bangkok: Ministry of Agriculture and Cooperatives, various years).

Notes: Percentages of total annual budget are in parentheses. Prices are adjusted to 1976 prices.

Table 18--Cost of large projects under construction in 1978 prices

| Region and Project | Type | Storage Capacity (million metric tons) | Area Covered (hectares) | Total Cost (million baht) | Cost per Hectare (baht) | Cost per Metric Ton of Paddy ^{a/} (baht) |
|----------------------|------|---|----------------------------|------------------------------|----------------------------|--|
| North | | | | | | |
| Phitsanulok | ID | --- | 139,520 | 6,300.0 | 45,150 | 457 |
| Kiu Lom Dam | SIFH | 112 | 8,320 | 323.0 | 38,820 | 382 |
| Mae Ngat Dam | SIF | 265 | 4,800 | 765.0 | 159,380 | 1,591 |
| Mae Kuang Dam | SIF | 200 | 22,400 | 582.6 | 26,000 | 259 |
| Central Plain | | | | | | |
| Greater Mae Klong | I | --- | 419,360 | 3,528.0 | 8,400 | 98 |
| Krasiao Dam | SIFD | 240 | 20,800 | 927.0 | 44,570 | 478 |
| Bang Ban | PD | --- | 21,920 | 300.0 | 13,690 | 189 |
| Northeast | | | | | | |
| Lam Pao Dam | SIFD | 1,340 | 54,080 | 1,400.0 | 25,890 | 363 |
| Nam Pong | ID | --- | 48,000 | 828.0 | 17,250 | 179 |
| Nam Un Dam | SIFD | 524 | 32,000 | 1,000.0 | 31,250 | 459 |
| Dom Noi | PD | --- | 24,000 | 500.0 | 20,830 | 278 |
| Huai Luang Dam | SIF | 113 | 12,800 | 345.0 | 26,950 | 334 |
| South | | | | | | |
| Pranburi Dam | SIFR | 445 | 35,200 | 1,332.0 | 37,870 | 830 |
| Pattani | ID | --- | 48,000 | 900.0 | 18,750 | 251 |

Source: Sukitti Krajangyao, Irrigation in Thailand, Bangkok Bank Bulletin (Bangkok: Bangkok Bank Ltd., January-June 1978).

Notes: D = drainage; F = flood control; H = hydroelectric power generation; I = irrigation; P = pumping; R = land reclamation; and S = storage of water.

^{a/}It is assumed that each hectare in the project will grow 30 crops of rice at constant yield.

There are also cases where costs per hectare are much different for the same type of project and the same area coverage if the projects are located in different regions; for example, Dom Noi in the Northeast and Bang Ban in the Central Plain.

The costs per hectare for each type of project, averaged over all regions, are: 27,050 baht per hectare for ID and SIFH projects and 33,050 baht per hectare for SIFD, SIFR, and SIF projects.

The costs per hectare for each region, averaged over all types of projects, are:

| | |
|---------------|-------------------------|
| North | 37,650 baht per hectare |
| Northeast | 24,430 baht per hectare |
| Central Plain | 22,220 baht per hectare |
| South | 28,310 baht per hectare |

COSTS OF MEDIUM AND SMALL PROJECTS

Medium projects develop water resources in unirrigated areas by building tanks, weirs, and other structures. Construction cost per project is 2-200 million baht. The average cost per hectare irrigated is about 19,290 baht.

Small projects are those whose construction costs do not exceed 2 million baht each and whose period of construction is no longer than one year. The nature of the projects includes distribution and drainage systems, storage, conservation, and flood control. However, small projects are designed to reduce the severity of water shortages. There is no complete system of canals or laterals as for medium- or large-scale projects.

In 1978, 330 small projects were constructed. Table 19 presents the area coverage and construction costs per hectare and per ton of rice produced by region. These costs vary a great deal from one region to another. The highest costs per hectare and per ton of paddy are incurred in the Northeast and the lowest costs are incurred in the Central Plain. This is probably because irrigation development has taken place mostly in the Central Plain. This, together with topographical conditions of the region, makes it relatively less costly to irrigate additional area in the Central Plain. This variation in costs per hectare among regions exists even when particular types of projects are considered (see Table 20).

Costs per ton of paddy not only vary because of the differing costs of irrigation of the different types of projects, but also because of the region and size of the area being irrigated. Although it costs less to construct a project in the Northeast than in the North and South, the small area covered coupled with the low yield per hectare results in high costs per hectare and per ton of paddy in the Northeast.

Table 19--Small irrigation projects constructed in 1978

| Region | Number of Projects | Area Covered (hectares) | Cost of Construction (million baht) | Cost per Hectare | Cost per Metric Ton of Paddy ^{a/} (baht) | Cost per Project | Area Covered per Project (hectares) |
|------------------|--------------------------|-------------------------------|---|---------------------|--|------------------------|---|
| North | 48 | 57,623 | 49.82 | 865 | 10 | 1,037,917 | 1,200 |
| Northeast | 240 | 26,090 | 168.82 | 6,471 | 86 | 703,417 | 109 |
| Central Plain | 24 | 36,320 | 11.71 | 322 | 4 | 487,917 | 1,513 |
| South | 18 | 14,386 | 18.42 | 1,282 | 17 | 1,023,333 | 798 |
| Whole Kingdom | 330 | 134,401 | 248.77 | 1,851 | 22 | 753,848 | 407 |

Source: Thailand, Ministry of Agriculture and Cooperatives, Royal Irrigation Department, unpublished data and previous tables on rice yields.

^{a/}It is assumed that each hectare in the project will grow 30 crops of rice at constant yield over the life of the project.

If the average cost of each type of project, regardless of size, is considered, these project types can be grouped by cost per hectare:

| 13,000-54,000 | 5,000-9,300 (baht/hectare) | 1,000-2,000 |
|---------------|-------------------------------|-------------|
| SIF | PD | ICD |
| SIFH | P | CF |
| SIFD | IPD | F |
| SIFR | ID | C |
| SI | ICR | CD |
| | I | |

The construction costs per hectare of an irrigation project, averaged over all types in each region, are:

| | |
|---------------|-------------------------|
| North | 15,500 baht per hectare |
| Northeast | 19,700 baht per hectare |
| Central Plain | 7,300 baht per hectare |

Table 20--Regional costs of construction of small irrigation projects by type of project, 1978

| Type of Project | Region | | | | Whole Kingdom |
|-----------------|----------------|-----------|---------------|-------|---------------|
| | North | Northeast | Central Plain | South | |
| | (baht/hectare) | | | | |
| I | 844a/ | 6,408 | 591 | 1,880 | 1,180a/ |
| F | 438 | --- | 2,000 | --- | 1,375 |
| C | 453 | 2,391 | 205a/ | --- | 329 |
| D | 625 | --- | --- | --- | 625 |
| S | --- | 5,052 | --- | --- | 5,052 |
| SI | 10,597 | 6,742a/ | --- | --- | 6,805 |
| CD | 2,063 | --- | --- | 806a/ | 831 |
| CDF | --- | --- | --- | 2,229 | 2,229 |
| Average | 865 | 6,471 | 322 | 1,282 | 1,851 |

Source: Thailand, Ministry of Agriculture and Cooperatives, Royal Irrigation Department, unpublished data.

Notes: C = conservation of water in the plains; D = drainage; F = flood control; I = irrigation; and S = storage of water.

a/The largest proportion of area covered by small projects in 1978 is under this type of project.

COSTS OF LAND CONSOLIDATION AND DITCHES AND DIKES PROJECTS

Land consolidation costs vary according to the work required for different types of area.

Type A is implemented in areas not deeply flooded and with small, irregular plots. The layout of ditches, drains, and roads is mainly determined by the topography rather than by the existing property boundaries. Land leveling is necessary because the plots are aligned. The cost of land consolidation for this type of area is the highest: 25,562.50 baht per hectare.

Type B is implemented in areas consisting of relatively large and more regular plots. The ditches, drains, and roads follow the existing property boundaries as much as possible. The work includes only minor realignment of plots, and land leveling is limited. The cost involved for such work for this type of area is about 20,812.50 baht per hectare.

Type C is for areas with a high degree of existing infrastructure that could be partially or completely incorporated into the new design. In principle, this is a development of type B, since the new tertiary system follows the plot boundaries. The construction cost in this case amounts to 17,750 baht per hectare.

Type D is the only type of work that could be implemented in areas where flooding to a depth of 100 centimeters may occur. It includes the construction of irrigation ditches along the plot boundaries and of a limited number of roads alongside major ditches. The cost for this type of work is only 8,625 baht per hectare.

The construction cost of ditches and dikes in the existing irrigation system is about 6,250-8,750 baht per hectare, depending on whether the construction is carried out by the Royal Irrigation Department or whether it is contracted out to private firms. If contracted out, the cost is about 40 percent higher.

From the cost and yield figures presented above, it appears that irrigating one hectare increases yield by 0.87 tons at a cost, on average, of about 1,850 baht, assuming that the irrigation project is small.

To increase yields further where an irrigation infrastructure exists, the choice is between the construction of ditches and dikes or of land consolidation; that is, the choice is between converting a hectare in category 3 into 2 or one in category 3 into 1. Ditches and dikes increase yields by 0.24 tons per hectare at the cost of about 6,250-8,750 baht per hectare. Land consolidation, on the other hand, raises yields by 0.50 tons per hectare at the cost of 13,000-15,000 baht per hectare. The yield increase and the additional investment requirements for the construction of land consolidation are about twice those for ditches and dikes.

7. PROSPECTS OF IRRIGATION

The irrigation objectives of the Fifth National Development Plan (1982-86) are to improve the irrigated areas so that existing dams and reservoirs (such as Lam Pao Dam and Dom Noi) can be used more fully. The specific implementation objectives are: to convert about 160,000 hectares of unirrigated area per year in the Northeast, North, and South into irrigated area in categories 4 or 3, which would bring about an increase in rice yield from 1.56 tons per hectare to about 2.5 tons per hectare; to transform about 80,000 hectares of irrigated area per year in category 3 in the Central Plain to category 2, which would increase the rice yield from 2.44 tons per hectare to 3.00 tons per hectare; to convert about 8,000 hectares of irrigated area per year in the North from category 2 to 1, which would increase yield from 3.00 tons per hectare to 3.76 tons per hectare; to irrigate an area of 32,000 hectares per year by pumping in the Northeast and other regions where water sources are sufficient, which would increase the rice yield from 1.88 tons per hectare to 3.13 tons per hectare; and to irrigate 8,000 hectares per year through construction of small projects, which would increase rice yield from 1.56 tons per hectare to 2.50 tons per hectare.

If irrigation development is completed according to the plans, by the end of the 1980s the area irrigated under each category and in each region would be as shown in Table 21, with a total irrigated area of 3.36 million hectares. As a result of irrigation expansion and improvements and the corresponding increase in yields, rice output in irrigated area is expected to increase. This increase will come from growth in wet-season rice production in irrigated area and from growth in dry-season rice production due to an increase in double cropping.

Under the assumption that the ratio of wet-season planted area to irrigated area under each category remains unchanged, the total planted area irrigated can be estimated to be 2.71 million hectares in 1986, which is an increase of 672,500 hectares over 1979 (see Table 22). As a result, the proportion of irrigated wet-season planted area to total planted area is expected to increase from 22 percent in 1979 to about 27 percent in 1986, with a consequent increase in the total wet-season yield. This is because yields in irrigated areas have been shown to be higher than in rainfed areas.

Although the planted area under each category of irrigation is expected to increase as a result of irrigation improvement, the largest increase will occur in category 4, which has the lowest yield. The proportion of planted area under this category will increase from 17.68 percent in 1979 to 24.73 percent in 1986, at the expense of the

Table 21--Planned irrigated areas by category of irrigation and by region, 1982-86

| Type of Project | North | | | Northeast | | |
|-----------------|-----------------------------|---|---|-----------------------------|---|---|
| | Area (1,000 hectares) | Percent of all Area under Category | Percent of Area in Whole Kingdom | Area (1,000 hectares) | Percent of all Area under Category | Percent of Area in Whole Kingdom |
| Category 1 | 40.00 | 6.00 | 55.32 | 2.50 | 0.56 | 3.45 |
| Category 2 | 89.56 | 13.43 | 5.60 | 72.10 | 15.84 | 4.50 |
| Category 3 | 467.83 | 70.16 | 51.68 | 136.89 | 30.07 | 15.12 |
| Category 4 | 69.45 | 10.41 | 8.93 | 243.64 | 53.53 | 31.33 |
| Total | 666.84 | 100.00 | 19.87 | 455.12 | 100.00 | 13.56 |

Table 21, continued--Planned irrigated areas by category of irrigation and by region, 1982-86

| Type of Project | Area (1,000 hectares) | Central Plain | | Area (1,000 hectares) | South | | Area (1,000 hectares) | Whole Kingdom | |
|-----------------|-----------------------------|---|---|-----------------------------|---|---|-----------------------------|---|---|
| | | Percent of all Area under Category | Percent of Area in Whole Kingdom | | Percent of all Area under Category | Percent of Area in Whole Kingdom | | Percent of all Area under Category | Percent of Area in Whole Kingdom |
| Category 1 | 29.81 | 1.61 | 41.23 | --- | --- | --- | 72.30 | 2.15 | 100.00 |
| Category 2 | 1,418.16 | 76.46 | 88.60 | 20.76 | 5.48 | 1.30 | 1,600.58 | 47.69 | 100.00 |
| Category 3 | 196.08 | 10.57 | 21.66 | 104.45 | 27.54 | 11.54 | 905.25 | 26.98 | 100.00 |
| Category 4 | 210.65 | 11.36 | 27.08 | 254.01 | 66.98 | 32.66 | 777.74 | 23.18 | 100.00 |
| Total | 1,854.70 | 100.00 | 55.27 | 379.22 | 100.00 | 11.30 | 3,355.88 | 100.00 | 100.00 |

Sources: Calculated from data in 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); and Thailand, Office of the National Economic and Social Development Board, the Office of the Prime Minister, "Water Resources: Report on Thailand -- Northern Natural Resources Survey, Part B," February 1975, Canadian International Development Agency under assignment to Underwood Mclellan & Associates, Ltd., Canada, in The Fifth National Economic and Social Development Plan (1982-86) (Bangkok: NESDB, 1982).

Notes: 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.

Table 22--Estimated rice output, 1986

| Type of Area | Wet Season | | | Dry Season | | | Total | | |
|--------------|----------------------------------|--------------------------------|-----------------------------------|----------------------------------|--------------------------------|-----------------------------------|----------------------------------|--------------------------------|-----------------------------------|
| | Planted Area (1,000 hectares) | Yield (metric tons/hectare) | Production (1,000 metric tons) | Planted Area (1,000 hectares) | Yield (metric tons/hectare) | Production (1,000 metric tons) | Planted Area (1,000 hectares) | Yield (metric tons/hectare) | Production (1,000 metric tons) |
| Irrigated | 2,705.52 | 2.99 | 8,102.76 | 910.74 | 3.54 | 3,221.90 | 3,616.26 | 3.13 | 11,324.66 |
| Category 1 | 55.03 ^{a/} | 3.51 | 193.16 | 72.30 ^{b/} | 3.87 | 279.80 | 127.33 | 3.71 | 472.96 |
| Category 2 | 1,354.41 ^{a/} | 3.23 | 4,374.74 | 461.77 ^{b/} | 3.52 | 1,625.43 | 1,816.18 | 3.30 | 6,000.17 |
| Category 3 | 626.98 ^{a/} | 2.97 | 1,862.13 | 356.22 ^{b/} | 3.52 | 1,253.89 | 983.20 | 3.17 | 3,116.02 |
| Category 4 | 669.09 ^{a/} | 2.50 | 1,672.73 | 20.45 ^{b/} | 3.07 | 62.78 | 689.54 | 2.52 | 1,735.51 |
| Rainfed | 7,437.48 | 1.43 | 10,635.60 | --- | --- | --- | 7,437.48 | 1.43 | 10,635.60 |
| Total | 10,143.00 ^{c/} | 1.85 | 18,738.36 | 910.74 | 3.54 | 3,221.90 | 11,053.74 | 1.99 | 21,960.26 |

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).

Notes: 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.

^{a/}The irrigated area planted in the wet season is 76 percent of irrigated area in category 1, 85 percent in category 2, 69 percent in category 3, and 86 percent in category 4.

^{b/}The irrigated area planted in the dry season is 100 percent of irrigated area in category 1, 29 percent in category 2, 39 percent in category 3, and 2.6 percent in category 4.

^{c/}The total area planted in the wet season is 82.8 percent of paddy area.

shares under categories 2 and 3. The proportion of planted area under category 1 will also increase slightly, from 1.21 percent to 2.03 percent, during the same period.

With an increased percentage of planted area under the category with the lowest yield, the expansion and improvement in irrigation is unlikely to increase the total yield from irrigated area. However, as water control and rice technology improve, growth in yield can be expected. It is thus assumed that the yield for wet-season rice in irrigated area will grow at the same rate during 1979-86 (1.2 percent per year) as it did during 1970-78.

Consequently, the wet-season rice output in irrigated areas is expected to increase by about 2.48 million tons between 1979 and 1986. This increase is brought about largely by the expansion of the total area irrigated and by the improvement of existing irrigated area so that a larger area under each category can be cultivated.

Area change alone accounts for about 72 percent of the increase in the total irrigated wet-season rice output, whereas the growth of yields accounts for 22 percent and the interaction of the increases in yield and in area accounts for about 6 percent of the total increase in output.

Dry-season rice production will increase as the practice of double cropping does. This will happen as the existing irrigated area is improved through the construction of ditches and dikes or land consolidation, giving better control of water for dry-season cropping.

As stated, dry-season cropping has been practiced mainly on the area under the first three categories of irrigation. In 1979 the area cropped in the dry season included all area under category 1, about 22 percent of the area under category 2, 30 percent of the area under category 3, and only about 2 percent of the area under category 4. If these percentages remain unchanged, the dry-season planted area can be estimated to be 711,560 hectares by the end of the Fifth Plan. This area will account for 21 percent of the total irrigated area at the end of 1986 and represent an increase of about 26 percent in dry-season cropping during the period 1979-86.

However, as the proportion of dry-season cultivated area in the total irrigated area is increasing, this ratio cannot remain constant. It is assumed that it will expand at the same rate as during the period 1975-79, 3.95 percent per year. This makes the estimated dry-season planted area 910,740 hectares or 27 percent of the estimated total irrigated area at the end of 1986.

In order to estimate the increase in dry-season output, the yield differences between categories of irrigated area are taken into account. Under the assumption that these yields remain constant, the dry-season output will increase by 1.13 million tons between 1979 and 1986, bringing the total to about 2.97 million tons by 1986.

Allowing for an increase in dry-season irrigated yield to take place at the same growth rate as in the period 1976-81 (about 1.12 percent per year), the increase in dry-season production would be 1.38 million tons, with a total output in 1986 of 3.22 million tons.

Thus, as a result of both the expansion and improvement of irrigated area and the expected growth in yields, the rice output in irrigated areas in the wet and dry seasons together is expected to increase by 3.86 million tons during the period 1979-86.

Apart from irrigation, an increase in rice output can result from other factors, such as an expansion of rainfed cultivated area, largely in the wet season, and an increase in rainfed yields. In the past the growth of rainfed planted area has been even more rapid than that of planted area under irrigation. As a result, the share of the latter in the total planted area has declined slightly, as can be seen in Table 14. Rainfed planted area could be expanded even further by extending cultivation into new land not planted with rice before, either by substituting rice for other crops in the existing area or by enlarging the area itself, by cutting down forests, for example. This, however, requires that the water supply, particularly rainfall, be adequate.

In the future it is assumed that the total paddy area will continue to grow at the same average rate as it did in the period 1973-78. There has been a sharp decline in the growth rate since 1973, which suggests that less and less land suitable for rice remains.

By using the estimates of paddy area and the proportion of paddy area planted in wet-season rice, the total wet-season cultivated area in 1986 is derived. It is 10.14 million hectares, a 12.31 percent increase during the period 1979-86. An estimated 2.71 million hectares of irrigated planting area is deducted from this figure to obtain the residual rainfed planted area, which is 7.44 million hectares or 73.3 percent of the total wet-season planted area.

To estimate output, the wet-season yields are assumed to grow at the same rate (0.8 percent per year) as they did in the 1970-78 period, resulting in an estimated total wet-season output of 18.74 million tons in 1986. The rainfed output is then derived by subtracting the irrigated output of 8.10 million tons from the total. Thus the rainfed areas contribute about 10.64 million tons or 56.76 percent to the wet-season rice output. This represents an increase of 1.34 million tons during the period 1979-86.

Table 22 presents the results of the estimated rice output at the end of the Fifth Plan. The total increase of 5.21 million tons during 1979-86 can be attributed partly to irrigation and partly to other factors. Irrigation accounts for 74.24 percent of the increase, 64 percent of which is derived from the wet season and 36 percent from the dry season.

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