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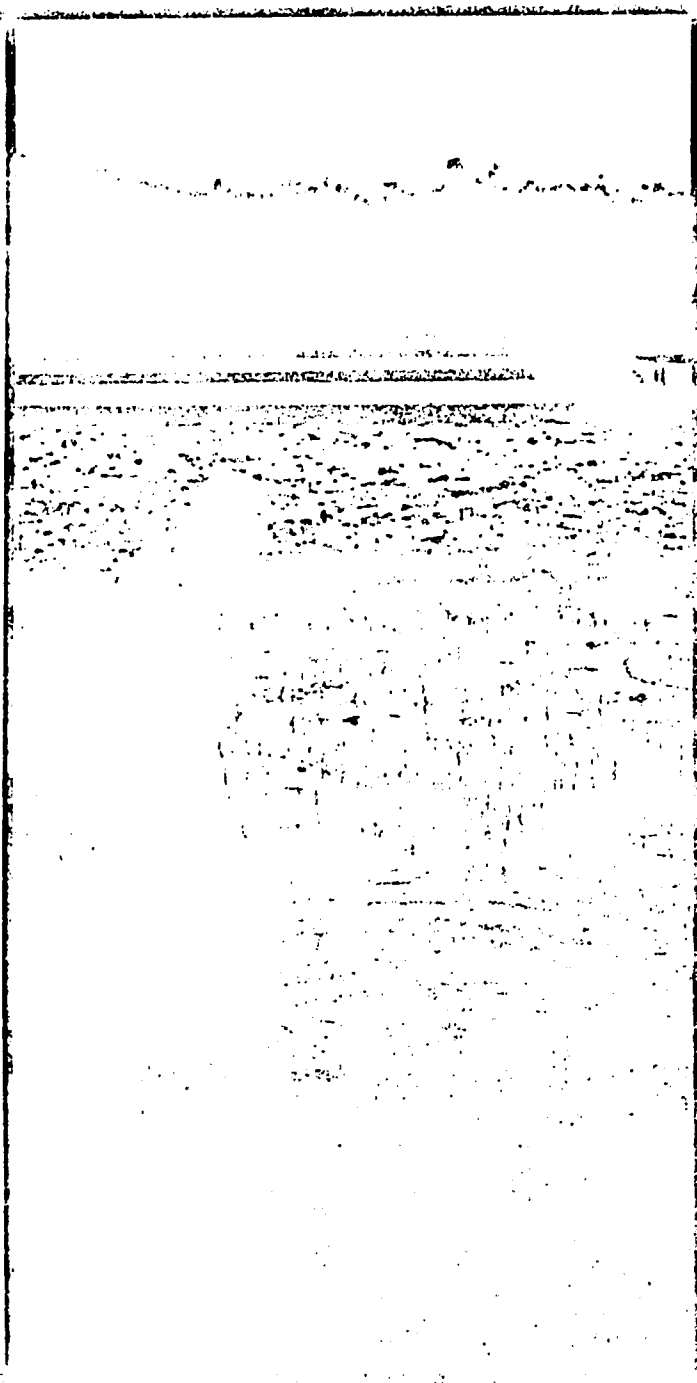

An Economic Analysis of Irrigation Development in Malaysia

Donald C. Taylor
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AN ECONOMIC ANALYSIS OF IRRIGATION DEVELOPMENT IN MALAYSIA

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and Mohd. Ariff Hussein[1]

The purpose of this paper is to review the status and performance of irrigation in Malaysia. The paper consists of 4 sections.[2] The first provides background information on the Malaysian paddy/irrigation sector. The second examines historical trends in Malaysian paddy production, and segregates the relative importance of different types of paddy, and area and yield, as sources of production growth. The third and principle section deals explicitly with irrigation. It focuses on the history of irrigation in Malaysia, investment over time in irrigation, and cross-sectional comparisons among different types and sizes of irrigation schemes. The paper concludes with the suggestion of priority areas for future research.

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[2]Unless otherwise indicated, the sources of data in the paper are the Triennial Reports of the Drainage and Irrigation Department issued between 1958-60 and 1970-72 (D.I.D., 1961, 1964, 1968, 1970, 1976), the 1946 Annual Report of the Drainage and Irrigation Department (D.I.D., 1948), the Annual Statistical Digests for 1963 to 1975 of the Ministry of Agriculture (M.A., 1965 to 1978), and Paddy Statistics, 1976 (M.A., 1978a).

I. MALAYSIAN PADDY/IRRIGATION SECTOR[3]

Malaysia is predominantly agricultural, with its agricultural sector accounting for about 49.5% of the country's working population, 45.5% of its total foreign exchange earnings, and 29.8% of its gross domestic product. Whereas the agricultural sector plays a critical role in the national economy, it also has a high incidence of poverty, estimated at 69% of its households (Bahrin, 1977, 21).

In 1974/75, about 12.3% of Peninsular Malaysia's cultivated land was under paddy (19.5% was under oil palm and 14.4% was under rubber), with slightly over 20% of Malaysia's working population involved in paddy production. More Malaysian farmers cultivate paddy than any other crop, with 55% of the country's 537,000 smallholdings having wet paddy. Paddy areas per farm are relatively small, averaging about 1.25 ha each and with about one-third of the farms having less than 0.8 ha of paddy land. Although many of the families[4] operating these small farms also earn income from non-paddy farm sources and off-farm employment (Goldman, 1975), about 88% of paddy households are still below the country's official "poverty line" (T.M.P., 1976, 164).

In 1974-75, Peninsular Malaysia's paddy growing area consisted of 372,352 ha of wet (bunded) paddy, about 80% of which is formally irrigated

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[3]Malaysia's irrigation is used almost exclusively for paddy - all its main season irrigated area and more than 98% of its dry season irrigated area in recent years are planted to paddy (see Appendix Table 1).

[4]The majority of exceptions are farmers in the Muda and Tanjong Karang Irrigation Schemes.

by the Drainage and Irrigation Department (D.I.D.), and 10,008 ha of dry paddy (Fig. 1). The D.I.D. irrigated area is organized in 556 separate schemes, the four largest of which are:

Muda in Kedah-Perlis, 101,215 ha;

Krian in Perak, 23,453 ha;

Tanjong Karang in Selangor, 19,856 ha; and

Kemubu in Kelantan, 19,028 ha.

Since these 4 schemes account for about 55% of the area and over 70% of the production from D.I.D. schemes, brief attention is given to the history and development of each scheme in Section III.

Irrigation accounts for 82% of the water currently demanded in Malaysia (the second largest using-sector, mining, accounts for only 10% of the quantity demanded). The relative importance of irrigation as a user of water is highest (over 98% of total demand) in Kedah, Perlis, and Kelantan and lowest (less than 70%) in Perak, Sarawak, and Selangor (D.I.D., 1976, 11-12).

From 1960 to 1974/75, Malaysia's annual population growth rate was 2.6% and her annual per capita income growth rate was 3.9% (F.E.E.R., 1978, 14). These growth rates imply a rapidly growing demand for rice. The growth rate in paddy production over roughly the same period of 6.2%, however, has enabled Malaysia to realize substantial progress toward realizing rice self-sufficiency (Fig. 2). In the 1950's Malaysia was 50 to 60% self-sufficient whereas in the 1970's the rate increased to

roughly 90%.[5] As will become clear in Section II, the main factor responsible for the increase in Malaysia's paddy production is a much expanded irrigated area during the dry season.

The following data help to place Malaysia in perspective relative to other Southeast Asian countries (Palacpac; 1978; 14, 30, 75-76, 124, 125, 132):[6]

- Malaysia's population of 12.5 million in 1976 is only 27 to 29% the population of Thailand and the Philippines, and only 9% that of Indonesia, thus implying that Malaysia has to support and service many fewer people than its neighboring agriculturally-oriented countries;

- Malaysia's population density of 202 people per sq km of arable land in 1975 was about 75% that of Thailand, 36% of the Philippines, and 28% that of Indonesia, thus implying a relative land abundance in Malaysia;

- Malaysia's proportion of labor force in agriculture in 1975 of 52% was about the same as that in the Philippines (50%), somewhat less than that in Indonesia (63%), and considerably less than that in Thailand (77%), thus implying that in terms of labor utilization Malaysia (and the Philippines) is less intensely agricultural than its neighboring countries;

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[5]Because rice "smuggled" from Thailand is not included in the self-sufficiency calculations, the extent of self-sufficiency reflected in Fig. 2 is some upward biased.

[6]Sources of information other than Palacpac (1978) are indicated below.

- Agriculture as a percent of GNP is considerably lower in Malaysia (31) than in Indonesia (40), about the same as in Thailand (30), and slightly more than in the Philippines (25) (F.E.E.R., 1978, 14);

- The average annual per capita income in 1974 of US$680[7] in Malaysia is slightly more than 2 times that in the Philippines and Thailand and 4 times that in Indonesia, thus implying that capital resources are relatively more abundant in Malaysia than in neighboring agriculturally-oriented countries (F.E.E.R., 1978, p 14);

- Malaysia's apparent rice consumption (kg/capita/yr) in 1975 of 110[8] is somewhat more than that in the Philippines (87), but considerably less than that in Indonesia (178) and in Thailand (209);

- Malaysia 1977 paddy production of 2,029,000 mt is only about 29% that of the Philippines, 14% that of the Thailand, and 9% that of Indonesia;

- Malaysia's 1977 paddy yield of 2.56 t/ha is about 94% that of Indonesia, but 33% and 52% more than that in the Philippines and Thailand, respectively;

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[7]The Ministry of Finance (M.F., 1978, 6) reports Malaysia's per capita income in 1978 to be M$2,490 (about US$1140).

[8]The Ministry of Agriculture (M.A., 1978a, 78) reports 118 as the apparent rice consumption in Malaysia for 1975.

- Malaysia's 1974-75 proportion of 37.5%[9] area planted to "modern" paddy varieties is considerably lower than that for the Philippines (61.5%), about the same as that for Indonesia (40.3%), and considerably higher than that for Thailand (6.6%);

- The price of fertilizer in 1977 relative to that of paddy in Malaysia (Selangor) was about the same as that in Indonesia (Central Java), but about 50% lower than that in the Philippines (Central Luzon) and Thailand (Suphan Buri); and

-The farm wage rate in 1977 in Malaysia (Selangor) was about 2 1/2 to 3 1/2 times as high as that in Indonesia (Central Java) and the Philippines (Central Luzon), and was about the same as that in Thailand (Suphan Buri).

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[9]During 1975-76, the three main varieties planted in Malaysia were Mahsuri (Mayang Ebos 802/Taichu 65 parentage, 132-135 days, released in 1965), Mat Chandu (not officially released), and Bahagia (Peta/Tangkai Rotan parentage, 137-145 days, released in 1968). The percents of planted areas to these three varieties in the main season were 21, 16 and 10, and in the dry season 21, 29, and 9, respectively (M.A., 1978a, 6, 30).

II. TRENDS IN MALAYSIAN PADDY PRODUCTION

The three "official" types of paddy production in Malaysia are "main season wet paddy," "main season dry paddy" (usually abbreviated "dry paddy"), and "dry season wet paddy." The "main season" corresponds to the period of highest monsoon rainfall, which in all areas of the Peninsula except the Northwest is in December-February. The Northwest's main season spans the period August-November. "Wet paddy" is bunded paddy, usually but not necessarily irrigated. "Dry paddy," on the other hand, is not bunded and therefore does not benefit from water retained during periods of heavy rainfall.

The Ministry of Agriculture collects and reports annual data on area, yield, and production of these three types of paddy. Area statistics are reported at the level of the sub-district (mukim). These reports reflect visual estimations of changes in areas relative to those in the prior season (Mohd Tamin, 1977). Occasional aerial surveys (e.g., in 1966 and in 1974) enable corrections to errors that arise from the subjective estimation procedure. The sub-district estimates are successively aggregated to the level of the district, the state, and ultimately the country.

Yields are based on crop cutting tests in the country's main paddy districts. The crop cuts were began in 1964. Although the crop cuts are based on scientifically sound procedures, they may give rise to upward biased estimates because they do not take into account handling losses and post-harvest damage (Jegatheesan, 1977).

Total production levels are computed from the area and yield data. These levels are reported separately for each type of paddy, and for the combination of all types of paddy. It is to these data that we now turn.

Total Rice Production

Part A of Fig. 3 and Fig. 4 portray graphically data on rice production during 1950-51 to 1976-77. (The raw data are reported in Table 23.) Total rice production increased from well below 400,000 tons in the 1950's to just over 1 million tons in the early 1970's. Since then total production has just held its own. The extent to which this reflects the relative scarcity of rainfall in recent years versus more basic structural causes is not clearly understood.

Until 1965, main season wet paddy was the only significant source of rice production. It continues to provide well over half the country's total production, but in the meantime dry season wet paddy has increased to the point where it accounts for almost 45% of the national total. Dry paddy never has accounted for more than 5% of total production, and in recent years its relative importance has dropped to less than 1%.

Prior to 1965, Penang (Muda and Kulim Schemes) produced by far the most dry season paddy. During the late 1960's the relative importance of Selangor (Tanjong Karang Scheme) and Perak (Krian Scheme) increased considerably. During the 1970's, however, Kedah (Muda Scheme) has taken

over as the main dry season paddy producing area (Fig. 5).[10]

Table 12 summarizes the current importance of each state and irrigation region[11] in total paddy production in the country. Kedah and Perlis alone account for slightly over one-half of Malaysia's production. The West Central Region, consisting of Perak, Selangor, and Penang, is next most important, accounting for just under one-fourth of production. Kelantan accounts for about 10% of production, and each of the East Central Region, the Southwest Region, and East Malaysia account for from 4 to 6% of production.

Paddy Area

Part B of Fig. 3 shows a modest increase in the area planted to main season wet paddy until 1961-62, but thereafter a levelling off and even a slight decline during the past 4 years. The area of dry paddy has also dropped some in recent years. Much in contrast to this is the very rapid increase from 1965-66 to 1973-74 in the area planted to dry season wet paddy. As a result, the cropping intensity, defined as the sum of the main season and dry season area divided by the main season area, increased from 1.0 in the 1950's and early 1960's to slightly over 1.6 in the past two years (Fig. 6).

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[10] Fig. 5 shows data for those states whose relative importance as a producer of dry season paddy has changed substantially over time. Kelantan is not included in the figure because its relative importance as a producer of rice in the mid-1970's (about 10%) is no different than it was in the mid-1960's.

[11] The basis for delineating the country into irrigation regions is indicated in Section III.

Paddy Yields

The yields of both main and dry season wet paddy have shown a sustained increase over the period of the study. Dry paddy yields, on the other hand, increased until the early 1960's, and since then have only held their own and even decreased in very recent years.

Sources of Growth

To gain a more precise idea about the overall rate of growth, and sources of growth, in total paddy production, the above data were subjected to a growth rate decomposition similar to that indicated by Johnston (1972, 48-50) and that used on agricultural data by Ashok (1966), Bhati (1973), and Shetty (1970). A semilog regression function[12] relating time to each of total production, area, and yield permitted us

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[12]The analysis supposes a variable Z growing at approximately a constant rate per unit of time t. We then have

$$Z_t = AB^t v_t, \text{ where} \quad (1)$$

$$B = 1 + g, \quad (2)$$

and in which g is a compound annual growth rate.
Taking logs of both sides of (1) gives

$$\log Z_t = \log A + (\log B)_t + \log v_t \quad (3)$$

We define $Y_t = \log Z_t$, $X_t = t$, $\alpha = \log A$, $\beta = \log B$, and $u_t = \log v_t$ (4)
and then rewrite (3) as

$$Y_t = \alpha + \beta X_t + u_t \quad (5)$$

Finally, taking the antilog of the estimated β and subtracting 1 gives the compound annual growth rate.

to determine the compound annual growth for these three variables for each type of paddy and for all types of paddy. Since revisions in area and yield data based on the 1966 aerial survey were extended back only to 1961-62, there is some discontinuity in the time series at that point. We therefore ran the regressions, not only for the entire period 1951-52 to 1976-77, but also separately for the pre 1961-62 and post 1961-62 periods. The results of the analysis are reported in Table 2.

Over the full 26 year period, total paddy production increased at an annual rate of 6.2%. About 2/3 of this increase is attributable to increases in area, and about 1/3 to increases in yield. The rate of growth since 1961-62 (5.2%) is somewhat more than that prior to 1961-62 (4.0%).[13]

The importance of growth in yields for total paddy production was greater during the earlier period. Thus, while the growth rates in total production are quite commendable, the reduced rate of growth in paddy yields in recent years is somewhat disquieting. This pattern, however, is not inconsistent with what has been reported recently in Asia by others (e.g., A.D.B., 1978).

This analysis also highlights the extent to which dry season irrigation is responsible for increases in overall production. Production in that

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[13]Several of the growth rates for the overall period exceed the growth rates in their respective component sub-periods. This arises because of the discontinuity in the time series data occasioned by the earlier mentioned revision up of area and yield data back to but not extending beyond 1961-62.

season expanded at an annual rate of 29.7%,[14] with the vast majority of the increase related to area expansion, particularly in the later period.

Main season wet paddy production increased by 3.2% each year, with area and yield increases of about equal importance. Again, however, the rate of growth in the later period is much less than earlier. For dry paddy, the situation is even more marked, with an 8.1% rate of decrease during the second period in contrast to a 10.6% rate of increase in the first period.

III. IRRIGATION DEVELOPMENT IN MALAYSIA

This section emphasizes the history of Malaysia's irrigation development, trends over time in the investment in irrigation and drainage, and cross-sectional comparative analyses by irrigation type and size of irrigation scheme. The basic objective is to try to derive insights from past experience that may enable more well informed decisions on the future development of Malaysia's irrigation and drainage resources.

History of Irrigation Development[15]

Our discussion is oriented around 6 distinctive periods in the history of Malaysian irrigation: pre-1900, 1900-32, 1933-42, 1942-45, 1945-49,

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[14] In interpreting this rate of growth, one should bear in mind the small initial level of dry season production.

[15] The main references consulted in developing this section are the D.I.D. Annual Report for 1946, the D.I.D. Triennial Reports for 1958-60 to 1970-72, the D.I.D. Manual (D.I.D., 1973), Cheong (1975), Finale (1977), Goldman (1975), Hill (1977), and Short and Jackson (1971). Additional references on the history of irrigation and rice policy in Malaysia are Doering (1973) and Lim (1977).

and post-1950. The key themes in the historical evolution of Malaysian irrigation are a shifting from imaginatively devised traditional irrigation technology (e.g., brushwood dams, water wheels, floating nurseries) to more modern irrigation technology, and a shift in emphasis from small-scale and privately-initiated to large-scale and government-initiated irrigation schemes (the last 3 to 4 years, however, see added government initiative being extended to small-scale irrigation).

Pre-1900, early history

The early history of rice in Malaysia is not fully clear. It appears, however, that rice was introduced some 2,000 years ago along rading waterways. There is quite firm evidence that paddy cultivation entered northern Malaya from Siam during the 15th century, and some argue that it came from the south as well. While there are no clear records of when rice cultivation entered East Malaysia, it is believed that "slash and burn" hill paddy may have been in Sarawak since the 1500's or 1600's and in Sabah since the 1700's.

Paddy cultivation in Peninsular Malaysia was introduced most successfully in the relatively flat coastal plains of Kedah and Pahang, and on a smaller scale in the long, narrow, and steep valleys of Negeri Sembilan. The type of irrigation development differed in these different areas.

In the flat coastal plains of Kedah, the main efforts at improved water control for paddy production were the drainage of swampy land and the introduction of "controlled drainage irrigation." The drainage of swamps involves nothing unfamiliar to us. "Controlled drainage," a type of irrigation to which we devote considerable attention later in this

section, involves controlling the exit of drainage water, and in so doing building up water levels to the point where water overflows nearby paddy lowlands.

In the early 19th century, the Sultan of Kedah constructed drains with the help of forced labor. Later on it became possible for individuals to receive land development "concessions" from the Sultans who, prior to British rule, controlled agriculture, trade and fishing activities. The concession involved the drain-developer receiving the right to construct drains, but at his own expense. In return, the drain-developer received strips of land on either side of his drains which could be sold to colonists and/or rented to them. Several of these privately developed drainage activities proved financially successful, with a result that by 1900 there was a quite extensive, though disjointed, network of such drainage channels in Kedah.

Perhaps the most famous early such drain is the Wan Mat Saman canal, extending 23 miles from Alor Setar to Gurun. This drain was developed in 1888, and it continues to be in service even until today.

In Pahang the so-called "paya" system developed. A "paya" is a relatively flat natural basin area, usually without a reliable water supply, that is dammed up prior to the planting season. The late monsoon rainfall and runoff thereby impounded, sometimes to a height of several feet, is used to thoroughly saturate the soil. At the time of planting, water is gradually released until the paddy seedlings can stand without being drowned. After that the paddy cultivation becomes essentially rainfed. This system continues to be found in the Pahang River Basin.

In the long, narrow, and steep valleys of Negeri Sembilan, water control for paddy cultivation involved "positive irrigation," through gravity-diversion of streamflows onto paddy land. The early development of these river sources, perhaps over 200 years ago, was commonly communal.[16] Two main types of indigeneous Malay technology used for achieving water control were brushwood dams and bamboo water wheels (kinchir). (Since these devices, through scarce, can still be found, the present tense is used in describing them).

The brushwood dams are locally-constructed weirs made of logs, bamboo pieces, matted sticks, and packed earth. These dams provide added water control under normal and sub-normal stream flow conditions, but of course are subject to washing out when stream flows become too powerful.

The water wheels, constructed entirely from jungle produce, are used to lift water to areas that cannot be commanded by simple gravity-diversion. Bamboo pipes are attached to the periphery of a wheel that rotates with the power of the stream current. Pipes fill as they dip in the water, and empty themselves into a trough as they rotate, with bamboo gutters taking the water to the fields to be irrigated. Such a system, though lacking in technical efficiency, requires no external energy supply and does not require continuous supervision.

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[16] As far as the authors know Malaysian communal systems have not been studied by social scientists.

The more complicated undulating terrain in Kelantan did not lend itself as readily to simple indigenous irrigation technology as the West Coast land. Nevertheless, there is some evidence of brushwood dams and "palm leaf scoops," beginning in the 18th century at Panggong Kubor, and for generations at the Chinese settlement at Pulai on the Gelas River. The original canals at Pulai were for gold washing; later they were expanded for use in paddy cultivation.

By 1900, some 245,000 ha of wet paddy are reported to have been under cultivation.

1900-1932, rubber in competition with paddy until the formation of the Drainage and Irrigation Management

This was a period in which the British emphasized the development of an estate type of agriculture (primarily rubber) in Malaya. Their liberal land and labor policies to encourage the development of rubber plantations and the immigration of laborers to work as rubber tappers placed rubber in direct competition with paddy for these of land and financial resources.

Nevertheless, there was a concern to also produce more food, with a result that policies were also adopted to encourage the immigration of those who would come to help develop new paddy land. Perhaps the most dominant immigrant group for paddy cultivation were the Banjarese from South Borneo (now Kalimantan). A common pattern was for a migrant to secure permission from a Malay chief to develop land. He would then offer passage and a money-advance to his fellow-countrymen as incentive for them to immigrate to Malaya. Many came to Malaya through this way, and the

pace of paddy cultivation picked up some. The revenues that came from such privately-developed land were shared with the Malay chiefs.

The Banjarese brought with them a "floating nursery" technology for overcoming problems of deep-water flooding of seedlings. They constructed nursery beds from fallow grass, banana stems, and leaf-ribs of sago palms, and let the mats lay on the ground for several weeks. Several mats were then stacked together, packed with mud, and placed in the water. Paddy was sown and the seedlings continued to float until water levels receded to the point where the seedlings could be planted without fear of drowning.

By far the dominant irrigation-even during this period was the initial completion in 1906 of Malaysian's first large-scale project, namely, the 20,240 ha Krian Project in Perak. Though other large-scale projects were not to be developed for decades, the experiences with this pioneering project paved the way technically (and psychologically) for later large-scale developments.

Elsewhere in the Peninsula relatively little irrigation development took place, except for effort to link up some of the Kedah and Perlis drains into more comprehensive drainage networks, and replace some of the Negeri Sembilan brushwood dams with more permanent headworks.

In 1913 an Irrigation Branch of the Public Works Department in the Federated Malay states was formed. Its objective was to carry out new water control works, primarily through collecting data and planning new schemes. It was not involved, however, with implementing new-scheme construction or maintaining existing schemes.

The growing population and declining paddy production that emerged during this period prompted the High Commissioner to appoint a Committee to explore possibilities for revitalizing and expanding paddy cultivation in Malaya. One of their main recommendation's was that a Drainage and Irrigation Department (D.I.D.) be created. Initially D.I.D. involved the Federated Malay States and the Strait Settlements; 5 years later Kedah and Kelantan were added. The main functions of the Department were (D.I.D., 1976, 5):

1. The improvement of irrigation and drainage facilities in existing paddy areas to increase rice yields.
2. The development of new areas for rice cultivation.
3. The construction of agricultural drainage schemes in coastal areas to improve the production of agricultural crops other than rice.
4. Maintenance and operation of drainage and irrigation schemes.
5. The maintenance and improvement of rivers, the natural drainage channels of the country (including dredging, flood mitigation works, river training schemes and river deviation schemes).

1932-1942, formation of D.I.D. until World War II

Until 1932, except for Krian, government-initiated water control for paddy cultivation in Malaya was primarily through drainage and controlled drainage. This period, then, saw the introduction of a variety of "positive irrigation" methods which continue even until today. Examples of these irrigation developments include the following.

- Sungai Manik, a 9,715 ha scheme in Perak was implemented via a five-stage program. This was Malaysia's first planned colonization irrigation scheme. The fourth phase was completed in 1941.

- Panjang Bedena, a 6,075 ha controlled drainage scheme completed in 1937, brought to Selangor its first paddy cultivation. Later on, as with several other controlled drainage schemes on the west coast, this scheme was converted to positive irrigation. It is now part of the Tanjong Karang Scheme.

- Pumping was first introduced in Perak, with a fixed-diesel engine pump in the 910 ha Bota Scheme in 1935, and with a floating pump in the 970 ha Pulau Tiga Scheme in 1936.

The outbreak of the war in 1939 put intensive pressure on Malaya to increase its food production. The primary emphasis was on bringing into cultivation 14,170 ha of additional land, through colonization, in Tanjong Karang. By 1942 much of the construction was completed.

1942-45, Japanese occupation

Drainage and irrigation more or less stagnated during the Japanese occupation. No new projects were constructed and the maintenance of existing projects was minimal.

Nevertheless, during this period a short-term Tawainese variety that could be grown during the dry season was first introduced. This made double-cropping become feasible.[17]

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[17] The scheme in which double-cropping first caught on was Sungai Kulim in Province Wellesley. It has its first double-crop in 1946. During the next 12 years only 115 ha in 2 other schemes in Malaya became double-cropped. The second medium-scale project to be double-cropped was the 6,520 ha Sungai Muda Scheme, also in Penang, that first began to be double-cropped in 1960.

1945-49, reoccupation of Malaya

The food production situation at this time was critical. Rehabilitation of schemes neglected by the Japanese was undertaken and within one or two years' time the planned area was restored.

A new constitution for the Federation in 1948 lead to certain administrative changes, including the establishment of state D.I.D.'s with their own budgets and staff. This pattern of a federal D.I.D. with national policy and project planning responsibilities, and state D.I.D. responsibility for project implementation[18] continues until today.

1950 to present, the era of Five-Year Plans

The historical analysis of capital investment in irrigation and the 1972 cross-sectional comparative analyses of different types and scales of irrigation schemes in the next two sub-sections, of course, fall within this most recent period. The discussion at this point is limited to a brief consideration of the four largest irrigation schemes in Malaysia, whose infrastructure was considerably intensified and expanded after 1950. We also give brief attention to two recent additional emphases in irrigation policy, viz., more intensive irrigation terminal infrastructure and small-scale irrigation.

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[18] Two exceptions are the large-scale Muda and Kemubu projects there are implemented under federal jurisdiction.

Muda scheme, Kedah-Perlis[19]

The muda scheme lies in a flat allevial plain, about 20 km wide and 60 km long between the foothills of the Central Range in the Peninsula and the sea. Over one-half the present scheme areas was initially under single-cropped paddy cultivation served by controlled drainage, and run-of-the-river supplemental irrigation (including brushwood dam facilities). The project was designed to increase the main season area to 101,215 ha and to bring double-cropping to the entire project.

The Muda scheme construction, financed by a US$45 million World Bank loan, was undertaken between 1966 and 1970. It involved the construction of the Muda and Pudu dams of concrete and rockfill construction, respectively, and the associated reservoir; a tunnel connecting them; a headworks and main canal system; improvement of the existing, and construction of new distributory canals, with secondary canals at approximate 1 km intervals and no tertiary canals; drainage construction; and ancillary works. The intention is for the Muda Scheme to receive about one-third of its water supply from each of streamflow, rainfall, and the Pudu reservoir.

The Muda Agricultural Development Authority, created in 1970, provides integrated management to the project. It is responsible to

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[19]The primary reference underlying the writing of this section is World Bank (1975). Additional references on economic aspects of the Muda Scheme include a series of "in-house" publications by the Muda Agricultural Development Authority (M.A.D.A.); Bell, et al (1976); Carter (1969); Doering (1973); FAO (1975); Lai (1977); Michio, et al (1976); and Slade (1975).

the Ministry of Agriculture, and governed by a Board of nine members from various federal and state agencies. The chief executive, the Project's General Manager, is also the Vice-Chairman of the Board. The General Manager is assisted in the execution of MADA's policies by three implementing divisions, namely, Engineering, Agriculture, and Industrial Development, and three supporting units, namely Planning and Evaluation, Publicity, and Administration.

Krian scheme, Perak[20]

As mentioned earlier, this is Malaysia's oldest large-scale irrigation scheme. Surveys and investigations on the scheme were started as early as 1880, and the project was finally completed at a cost of M$1.6 million in 1906. With the Bukit Merah Reservoir, the project was intended to have enough water to irrigate a single crop throughout the 25,100 ha command area. Experience proved, however, that the capacity of the reservoir was inadequate in some years to permit this.

Because of a national need to increase food self-sufficiency, a plan costing M$25.5 million was developed in the 1950's to ensure adequate water for the main season and convert Krian into a double-cropping area. The plan was implemented in three phases. The Phase I Extension, completed in 1968, increased the capacity of the Bukit Merah Reservoir so as to ensure adequate water for the entire 25,100 ha main season area, and 12,150 ha during the dry season.

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[20]The primary reference on which this discussion is based is Abu Bakar (1963).

The Phase II Extension, initiated in 1966, was aimed at rehabilitating Krian's reticulation system, alleviating flooding on 4,050 ha of riverine area, and checking erosion on an additional 2,025 ha. The Phase III Extension, also initiated in the late 1960's, was intended to provide a pumping source to supply the remaining 12,950 ha of the scheme with a reliable water supply during the dry season.

In 1978 an Integrated Agricultural Development Project for the Krian and Sungai Manik Schemes was initiated. About 45% of the project's total cost of M$144.4 million is being financed by a World Bank loan. Krian is receiving slightly over one-half (M$77 million) of the project investment. Information on the utilization of these funds is not yet available to the authors.

The Integrated Project has a Coordinator under the Ministry of Agriculture, who is guided on policy matters by a Steering Committee composed of the Federal Secretary General of Agriculture, the State Secretary of Perak, and other senior officials nominated by them.

Tanjong Karang, Selangor[21]

As mentioned earlier, the development of what is now called the Tanjong Karang Scheme began in the 1930's. The basic overall objective of this development was to convert 19,856 ha of peat-swamp into a double-cropped paddy area. It began with the development of controlled drainage facilities for the 6,075 ha Panjang Bedena component, which later was converted into gravity-diversion "positive irrigation."

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[21]The basic reference used in this write-up is Agarwal (1964). We are yet to obtain information on how Tanjong Karang developed since the early 1960's.

An additional component of the development was the installation in 1960 of a pumping station at Bagan Terap to irrigate 2,630 ha from the Bernam River.

Kemubu, Kelantan

Kemubu, like many other present-day schemes, started out with one or more smaller and simpler projects. For Kemubu, 4,860 ha of land had already been developed under the Bukit Abal, Sungai Anal, and part of the Salor Irrigation Schemes, and was later incorporated into what has eventually become the 19,028 ha Kemubu Scheme.

The most intensive component of the Kemubu development was initiated in June 1967. The M$76 million investment in infrastructure was assisted with a US$10 million loan from the World Bank. A pumping station, with 5 diesel driven pumps, was installed at Kuala Kemubu. These pumps draw water from the Kelantan River and direct it through a supply canal to the project area. To some extent, the supply canal serves as a reservoir as well.

A Kemubu Agricultural Development Authority (K.A.D.A.), similar to M.A.D.A., was established in the early 1970's. This authority provides coordinated management, not only to the Kemubu Scheme, but also to three other pumping schemes: Lemal (9,310 ha), Pasir Mas (2,025 ha), and Salor (1,660 ha).

We conclude this sub-section by noting two special features of Malaysian irrigation policy in the late 1970's: the intensification of terminal infrastructure and the developing of small-scale irrigation schemes.

Pang (1979) describes the intensifying of terminal irrigation and drainage infrastructure as the third phase (following phase one to ensure water supplies for single-cropping and phase two to enable double-cropping) in Malaysia's irrigation development.

Intensifying terminal infrastructure in Malaysia involves a variety of approaches, including (1) changing from earth-lined channels to concrete-lined channels or overground fiberglass reinforced polyster flumes, (2) increasing the density of tertiary and quarternary channels, and (3) intensifying on-farm water management. Until now, major attention has been given to converting earth-lined to concrete-lined channels.

By far the largest project for terminal infrastructure intensification in Malaysia is just now being implemented in the Muda Scheme. This program calls for an additional investment of about M$485/ha to intensify the terminal irrigation, drainage, and road infrastructure. Average irrigation channels densities (mt/ha) are to increase from roughly 10 to 30 and the drainage channel density to about 15.

Malaysia is also implementing a National Small Scale Irrigation Project with the assistance of approximately M$40 million World Bank loan. The project emphasizes improving existing schemes of less than 1,200 ha each. The details of this scheme are not yet available to the authors.

Investments Over Time in Irrigation

Five-Year Plans

We first look at Five-Year Plan macro-data on irrigation and drainage (Table 3). The total budgeted public development expenditure on drainage and irrigation increased by more than 12 times (a "real" rate of increase of 10.5 times) from 1950-55 to 1975-80. During the 1970's about 13% of the total agricultural and rural development expenditure was budgeted for drainage and irrigation,[22] whereas during the prior 5 years slightly over 30% was. The lack of earlier corresponding data preclude our knowing whether these data indeed reflect a longer term de-emphasis on drainage and irrigation relative to the rest of agriculture and rural development.

In the 1950's and early 1960's, the main emphasis in paddy land development was on main season production. From 1965 to 1975, however, the relative emphasis shifted much toward increasing the double-cropping capability. Within the main season, except for 1950-55, the primary emphasis has been on improving existing agricultural areas rather than extending agriculture and irrigation into new areas.

Of the total "drainage and irrigation" allocation, about 75% has generally been for "irrigation" (Cheong, 1975, 7). In the present Five-Year Plan, however, relatively more emphasis, at least in terms of area,

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[22] In the Third Malaysia Plan (1975-1980), the two items in the "agricultural and rural development" expenditure category that are larger than drainage and irrigation are land development (42.4%) and rubber replanting (14.3%).

is being given to drainage. Much of this area is concentrated in the West Johore Project, which contemplates massive changes in crop patterns (e.g., a major shift from rubber to oil palm, a substantial increase in cassava, more intercropping with coconut) after the installation of improved drainage and coastal bund facilities.

Drainage and Irrigation Department expenditures

Drainage and Irrigation Department annual expenditures include "development plan" expenditures for capital construction, as well as staff salaries, and other annually recurring expenditures (Table 4 and Fig. 9). The expenditures were deflated to a 1959 base. The "real" expenditures rose 3 to 4 times from 1959-1960 to 1971-1972. The expenditures in 1967-1969 were even higher than those in subsequent years, however, because of heavy investments during this period on the Muda Scheme and Kemubu Scheme infrastructure.

Capital construction investments

D.I.D. has developed considerable land during the past 15 years. For example, by the early 1960's D.I.D. had developed about 215,000 ha, whereas by the mid-1970's the area had risen to almost 300,000 ha (Fig. 7). As a result, the percent irrigable land (defined as the D.I.D. area as a percent of the total main season paddy area) increased over the same period from about 60% to slightly more than 75% (Fig. 8).

The irrigation capital construction cost data in the Triennial Reports of D.I.D. are reported separately for "(positive) irrigation,"

"controlled drainage," and "sub-standard/under construction" scheme. Since the third category is rather ill-defined, we have not given special attention to it.

Cummulative "capital construction: cost data are reported in each successive Triennial Report. To obtain a more precise idea on investment changes over time, we deflated[23] these data to a 1960 base (Table 5). The cumulative expenditure until 1960 was M$57.7 million. By 1969 the "real" expenditure had more than doubled, with about 20 times as much spent on irrigation as on controlled drainage. The next three years saw a 2.8-fold increase in the "real" irrigation construction costs, reflecting the substantial investments in the Muda and Kemubu Schemes.

The cumulative "real" capital construction costs were also reduced to a per hectare basis (Fig. 10). To do this, total cumulative real capital costs were divided by the total planned irrigation scheme area in each succeeding period. The result shows a rapid escalation in the "real" cost of irrigation development, although it is not possible to infer from Fig. 10 the "real" cost of the incremental area of new

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[23]The procedure was to compute the increment in capital construction costs in each three-year period succeeding 1960, to deflate that increment by an appropriate consumer price index (CPI) value (Malaysia has no wholesale price index), and to add the increment to the prior deflated cumulative total. Thus assuming Ct_0 is the base year construction cost, the deflated cost for the current year $Ct_1 = Ct_0 + (Ct_1 - Ct_0)/It_2$, where Ct_2 is the current year nominal cumulative construction cost and It_2 is the CPI for the same year (expressed to a base of 1.00). The real cumulative construction cost for the following year $Ct2 = Ct_1 + (Ct_2 - Ct_1)/It_2, \ldots, Ct_n = (Ct_{n-1} + (Ct_n - Ct_{n-1})/It_n$.

project investment and improved project investment during each period.[24]

The cumulative total "real" capital construction cost data as of 1972 were also analyzed by state and region (Table 6).[25] The Muda Scheme accounts for just over one-half of the total "real" investment in Malaysian irrigation. Both it and the 15.2% spent on the Kemubu Scheme are larger than the total for any individual state. There are also general tendencies for larger capital construction investments in northern than in southern states, and in West Coast than in East Coast states. As pointed out in Section III, West Coast states have more productive soils than East Coast states.

Maintenance costs[26]

The annual maintenance costs for DID irrigation schemes were also deflated to a 1960 base (Table 7). The total expenditure in 1969 was

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[24]Since these expenditures are cumulative rather than incremental (by period), their interpretation is somewhat ambiguous. However, time did not permit a more disaggregate analysis in which we could segregate investments to construct new projects from those to improve existing projects, and thereby be able to give a clear interpretation of the investment per hectare for the incremental area involved in each type of irrigation investment.

[25]The basis for delineating the country into regions is indicated in the next sub-section.

[26]In Malaysia, irrigation maintenance is commonly done on contract. Sometimes, however, the contracts are awarded to those within irrigation communities.

about 1.7 times as much as that in 1960, with 15 to 20 times as much allocated to irrigation as controlled drainage projects. The level of maintenance, like the capital construction costs, rose much (viz., about 60%) between 1969 and 1972.

The "real" annual maintenance costs were also reduced to a per-hectare basis (Fig. 11). The "real" maintenance cost for irrigation schemes went up by over 60% from 1960 to 1972, reflecting some combination of more intensive and/or less efficient maintenance in recent years. The per-hectare maintenance cost for controlled drainage schemes more than doubled between 1960 and 1966, but dropped substantially thereafter.[27]

Cross-Sectional Comparative Analyses of D.I.D. Irrigation Schemes[28]

This sub-section presents descriptive information on the different types of irrigation in Malaysia, and the different sizes of Malaysia's

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[27] The per-hectare maintenance cost for all types of projects increased by 2.3 times from 1960 to 1972, a more rapid rate than for either sub-component shown in the table. This must imply that per-hectare maintenance costs on "substandard/under construction" schemes went up well over 2.5 times, but whether this could really have happened and, if so, how to interpret it are not clear.

[28] A "D.I.D. irrigation scheme" has had some infrastructural attention from D.I.D. This section, therefore, omits attention to purely communal irrigation schemes. As far as we know, data on the number of schemes and area covered by communal irrigation are non-existent. Since 68 to 70% of planted main season wet paddy during the 1970's involves D.I.D. land, however, we can infer that the maximum possible proportion of communally irrigated land is 30-32%. In reality, the proportion is less than this because some "wet (bunded) paddy" is rainfed.

irrigation schemes. Six irrigation regions within the country are identified and described. We then analyze the relationship between irrigation type (and where feasible between scheme size and irrigation region as well) and the cost of irrigation, the area-impact of irrigation, and the yield of paddy under irrigation.

Irrigation scheme types

Malaysia has three basic types of irrigation: pumping, gravity, and controlled drainage. All pumping schemes tap river sources of water, i.e., until now sub-surface water has not been used for irrigation.[29] Except for Muda and part of Krian which have reservoir-storage, all other gravity schemes involve run-of-the-river diversion. The nature of "controlled drainage" irrigation was briefly noted earlier in this section. Since this type of irrigation may be somewhat unique, we shall elaborate a bit more the nature of controlled drainage schemes.

Controlled drainage involves stopping the flow of water in drainage channels before the water exits through tidal gates into the sea. As the water level builds up inland from the tidal gates, the water overflows the flat surrounding land (or the water table rises beneath the surrounding land), and thereby becomes a water source for paddy cultivation.

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[29] An exception is the recent pilot Meranti Project that involves pumping underground water for paddy cultivation. This project is in Kelantan, whose underground water supply is more abundant than that in any other state in the country.

Since the build up and maintenance of water levels adequate to cover designated paddy areas is directly dependent on drainage flows, the degree of water control with this type of irrigation is relatively limited. A second shortcoming of this type of irrigation is that water supplies are stagnant, rather than flowing as with "positive irrigation." On the other hand, costs of constructing such schemes (unless extensive coastal bunds to prevent salt-water intrusion are required) can be expected to be relatively low, a point confirmed below.

In 1972, the last year covered in the last available D.I.D. Triennial Report, Malaysia had 556 D.I.D. irrigation schemes, with an average area per scheme of 540 ha (Table 8).[30] Almost 55% of these schemes involve gravity-flow irrigation; they cover almost 73% of the D.I.D. irrigated area, and average about 720 ha each. About one-fourth of the schemes involve controlled drainage, but these schemes are so small that they account for only 5.5% of the total irrigated area. Pumping schemes are least numerous, but they account for over one-fifth of the irrigated area.

Irrigation scheme sizes

D.I.D. irrigation schemes vary from 11 ha (Paya Dehilir Scheme in Pahang) to 101,215 ha (Muda Scheme) in size. A size-class frequency distribution of the 556 irrigation schemes (Table 9) shows that:

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[30] The data on which Tables 8 and 11 are based are shown in Appendix Table 3.

- 90.4% of the schemes consist of 500 ha or less each, and that they account for 17.4% of total irrigated area but only 7.9% of total production;
- 4.1% of the schemes consist of between 501 and 1,000 ha each, and that they account for 5.0% of land area but only 3.0% of production; and
- 5.5% of the schemes exceed 1,000 ha each, and that they account for 77.6% of land area but 89.1% of production.

These data, of course, imply that the smaller schemes have lower output per unit of planned scheme area. We are yet to determine the extent to which this outcome reflects a lower utilization of small-scheme land (data on fallow land, by state, are shown in Table 19), and/or lower yields on small-scheme land. Particularly because of renewed interest in small-scale irrigation in Malaysia, and elsewhere in Asia, we would submit that exploring differential agricultural performance in schemes of different sizes is a research topic of high priority.

Irrigation regions

The resource-base from region to region within any country varies. Using only national-level aggregate data in analysis, therefore is often sub-optimal. Since we are unaware of Malaysia having already been broken down into irrigation sub-regions, we searched for a way to do it. Time and intellectual resources did not permit a rigorous approach to this task. Taking into account the above information and some additional

data,[31] however, we conclude that Malaysia could be construed to consist of 6 irrigation regions, as indicated in Fig. 1 and Table 10. (The discussion below also refers to Table 11, which shows mean planned areas per scheme, and Fig. 12 which shows the average annual rainfall distribution and average annual rainfall of selected rainfall stations in Malaysia).

Northwest. Gravity-flow irrigation is dominant in this region. Over 96% of the regions's irrigated area is supplied with water via gravity, and 52% of the nation's gravity flow area (Appendix Table 3) is in this region alone. A second distinguishing feature of this region is its above average scheme-size; this derives from the fact that much of the area is a flat coastal plain.

The rainfall pattern in this region is somewhat unique (the neighboring states immediately to the south have some of the same characteristics, though to a lesser extent) in that the seasonal low is in December to February at a time when the rest of the Peninsular enjoys substantial rainfall. Its two peaks are intermonsoonal, viz., in April-May and September-October.

West Central. Gravity-flow irrigation dominates this region (83.8% of its total area), but there are also pumping schemes (15.9%). Schemes

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[31]The additional data are primarily from Wong (1971), the D.I.D. Triennial Reports, and D.I.D's Manual.

tend to be relatively large. The region has two seasonal peaks in rainfall, viz., during the March-April southwest monsoon and the October-November northeast monsoon periods.

Northeast. Pumping schemes dominate this region to the same extent that gravity-flow schemes dominate the Northwest.[32] These schemes are also above-average in size.

Seasonality of rainfall distribution is more marked in this region than in any other in Malaysia. It has only one primary maximum period, viz., during the October-January northeast monsoon period when, on the average, roughly 63% of its annual rainfall is received.

Although the Kelantan River Basin forms a generally flat plain area, the terrain within it is gently undulating. This feature results in a non-contiguous irrigation command area and makes more difficult achieving a uniform geographic distribution of irrigation water. Soils in this region and in the East Central Region also are less productive than those on the West Coast.

East Central. "Controlled drainage" irrigation[33] is more dominant in this region than in any other. For example, over 87% of Malaysia's

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[32]Kelantan's first pumping schemes were the 1,620 ha Salor Scheme in 1951, the 1,820 ha Pasir Mas Scheme in 1957, and the 9,310 ha Lemal Scheme in 1963.

[33]As explained above, the "paya" irrigation of Pahang is technically somewhat different than controlled drainage. For purposes of broad classification, however, "paya" irrigation clearly corresponds more closely to controlled drainage than to the other types of irrigation.

controlled drainage area (Table 24) is in this region alone. Within the region itself, slightly over half the area is irrigated by controlled drainage water sources. Slightly more than half of the remaining area is pump irrigated, with the clear implication that this region has by far the most diversified sources of irrigation of any in the country.

Its rainfall pattern is similar to that in the Northeast, but with a somewhat less marked seasonality of distribution. Its irrigation schemes, however, are much smaller than those in the Northeast. This is because much of the region's paddy land rests in narrow valleys with small catchment areas. Further, water sources generally are inadequate to support double-cropping.

Southwest. As elsewhere on the West Coast, gravity-flow irrigation in this region is more importnat than any other irrigation-type. This region has a larger proportion of pumping (28.9% of its area) than the region's to the north, however.

The distribution pattern of rainfall in this area is generally similar to that in the West Central region. Compared to all other regions in the Peninsula, the extent of seasonality in rainfall in this region is least marked. Its irrigation schemes are small, again because they rest in long, narrow valleys with limited catchment areas.

East Malaysia. Convenience rather than rational criteria underlie the grouping together of Sabah and Sarawak. While East Malaysian irrigation is more recent than irrigation in Peninsular Malaysia, this is especially so in Sarawak which began realizing irrigated paddy production only after 1972.

In the next three sub-sections that analyze relationships between (1) scheme type, scheme size, and irrigation region and (2) irrigation costs, irrigation area-impact, and scheme yields, explicit attention is given to irrigation schemes with more than 10,000 ha of irrigation area each (viz., Muda, Kedah-Perlis, gravity; Krian, Perak, gravity; Tanjong Karang, Selangor, gravity; and Kemubu, Kelantan, pumping). In particular, we examine the impact of including, or excluding, these 4 projects on the average values calculated for schemes throughout the country. The impact is often considerable in that these 4 "giant" schemes account for 53.6% of the total D.I.D. irrigated area and 72.8% of total D.I.D. paddy production (recall Table 9). To not include them[34] would be to omit attention to the dominant component of irrigation in the country, but to include them could be expected to result in the computation of average values that sometimes do not represent well the conditions for the country's other 552 projects.

A presupposition of these comparative analyses, from the standpoint of the possible applicability of the results of analysis to irrigation policy-makers, is that in the longer run a country has some option to emphasize making investments in projects of different types, different sizes, and/or different regions. We recognize, however, that technical factors surrounding particular water sources sometimes permit only one

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[34]When they are excluded from the body of a table, the table title has the words, "small and medium scale irrigation schemes."

approach for developing the water sources, and that policy decisions are sometimes influenced more by political than economic factors.

Irrigation costs

As mentioned earlier, the data reported by D.I.D. on capital construction costs are cumulative over time. To disaggregate these data to the level of individual schemes and to isolate when additional investments were made in each scheme would be a very substantial task. Without such a procedure, however, dealing satisfactorily with the influence of inflation on scheme-costs is not possible. Until now, however, we have not faced this challenge squarely. In other words, we have used the data on cumulative nominal construction costs incurred until Devember 31, 1972 in our analysis of the different categories of schemes. To the extent that investments in the various types and sizes of irrigation schemes, and schemes in different states and regions of the country, have been made simultaneously, the fact that investments for constructing individual schemes were not deflated will not cause our comparative analyses[35] to suffer. To the extent that irrigation development has not been balanced in these ways over time, however, the failure to deflate the cost data will have introduced distortions. Except for the Muda and Kemubu schemes involving substantial investments during very recent years (which is taken into account in our analysis, as explained above), we do not know whether

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[35] Interpreting absolute levels of cumulative nominal construction costs is, of course, problematic.

Malaysia's irrigation development has been balanced within these contexts. Clarification concerning this issue will be sought from the D.I.D. In the meantime, we examine the results of analyzing the cumulative nominal cost data.

The mean construction cost per hectare for Malaysia's 556 irrigation schemes is M$1,410 (Table 12). This mean is heavily influenced, however, by the Muda Scheme investment of M$2,132/ha[36] and the Kemubu Scheme investment of M$4,028/ha.

Disregarding the investments in these 2 projects and those in Krian and Tanjong Karang as well, the mean construction cost is M$796/ha. The pumping schemes are most costly - 35% above average, and the controlled drainage schemes are least costly - only one-half the average. This finding suggests that diversion headworks are generally less costly than pumping facilities, and that the lack of special purpose diversion structures and the less extensive water distribution network in controlled drainage schemes reduce substantially their costs of construction.

The inclusion of the 4 largest irrigation schemes has little effect on per-hectare maintenance costs. The average expenditure (M$/ha) in 1972 for all irrigation types was 45, with pumping schemes requiring 31% above-average maintenance. Maintenance expenditures in the controlled drainage schemes, on the other hand, were very low - only 28% of the national average.

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[36] The Muda Post-Project Completion Report (World Bank, 1975, 3) indicates that "the final project cost (without interest during construction) was M$245 million (US$840/ha)."

Since disaggregate data on operation costs are not readily available, our analysis could not give attention to this component of irrigation costs. Particularly because fuel costs for pumping schemes are "high,"[37] our comparative analysis on type of irrigation is incomplete. Even without a consideration of operations costs, however, our analysis shows pumping schemes to be considerably above-average in cost and controlled drainage schemes to be considerably below-average in cost.

Where technical factors permit developing a water source by more than one way, a more costly approach cannot be justified unless it leads to higher and/or more stable agricultural output. With pumping schemes, one would expect a maximum possibility for good water control and therefore a high level of agricultural performance, and with controlled drainage the lowest possibility of good water control, and hence the poorest agricultural performance. These considerations led us to hypothesize that, other things the same, pumping schemes would have highest and most stable yields, and controlled drainage schemes the lowest and least stable yields. To test these hypotheses, we examined, with existing secondary data, differences in the actual performance of different types of irrigation schemes. To reduce at least somewhat disturbances by other factors-not-the-same, we chose to make our comparison among schemes within only one state.

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[37] An illustration may be helpful. Fuel costs are currently about M$7,000 per day of pump operation in the 16,194 ha Kemubu Scheme, which would imply an expenditure of well over M$125/ha per year for fuel alone.

As mentioned earlier, Pahang is the only state with a full range of irrigation-types. We therefore selected randomly 10 schemes of each irrigation-type, and recorded planted areas and yields per ha for as many years as data were available. For most projects, this involved 1959-60 to 1974-75, minus 3 to 4 years for which data were unavailable.

For each project, the mean planted area and mean yield over time were computed; coefficients of variation for the same data were also computed. The mean planted area was compared with the planned scheme area to gain some idea on the extent to which actual water supplies may have been adequate to irrigate the areas originally intended for irrigation.

Table 13 summarizes the results of this rather simple analysis. Only in a few cases were the hypothesized results confirmed. Yields in controlled drainage schemes were indeed lowest, but the yields in gravity schemes exceeded those in pumping schemes. The year-to-year stability of yields is not greatly different among irrigation-types but, to the extent that there may be differences, it would appear that pumping scheme yields are slightly less stable and gravity scheme yields are more stable than average.

The mean cropped areas as percents of the planned scheme areas are clearly lowest for the selected pumping schemes and highest for controlled drainage schemes. Year-to-year variations in planted areas are the highest for pumping schemes and least for controlled drainage schemes. Both these findings are the exact opposite of what was hypothesized. It is conceivable that examining larger samples of projects, obtaining more

precise data, examining a larger number of project characteristics, and/or analyzing more thoroughly available data would produce different results. In the meantime, we are left with the possible suggestion that higher cost pumping irrigation in Malaysia may not be justified on economic grounds.

The pre-hectare costs of irrigation were analyzed separately for groups of schemes falling within individual size-classes (Table 14). While this analysis is too simple to be of much value, it appears clear that the smallest irrigation schemes (of less than 100 or 200 ha each) are most costly, from the standpoints of both construction and maintenance. The former are undoubtedly explained by the traditional "spreading-of-overhead" argument, the latter by the added expense of moving personnel and/or equipment from one small project to another. While there appears to be some tendency for middle-sized projects to be least-costly, a more rigorous and statistical analysis of the data is required before definite conclusions can be drawn.

The analysis of irrigation costs by state and region (Table 15)[38] indicates greater variability among states in per-hectare construction costs than in maintenance costs. Both types of costs appear to be influenced by factors other than regional location, i.e., there are no clear patterns

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[38] In interpreting this table, the reader should bear in mind that the areas of some types of irrigation in certain states are very small (see Table 10), and therefore their costs should not be taken too seriously. Further, he (she) is cautioned to not pay much attention to the average costs for all types of schemes. The variations in costs within scheme-types tend to be masked by variations among scheme types.

of certain regions being high cost and others low cost. Even among individual states relatively little can be concluded other than that construction costs are relatively high in Perak for pumping and gravity schemes and in Pahang for controlled drainage schemes.

Irrigation area-impact

A key issue in irrigation policy strategies is whether irrigation investments should be made to intensify production in existing agricultural areas or to extend agriculture into new areas. Related issues are the extent to which irrigation investment is intended to increase double-cropping and the extent to which intended cropping intensities are actually realized in practice.

Table 16 shows data on the areas under cultivation prior to investment in irrigation and the intended scheme areas after irrigation. For Peninsular Malaysia as a whole, irrigation is intended to extend the cultivated area by 66%. This area-extension is by far the greatest in the West Central Region (especially in Selangor and Perak), and least in the Northwest Region. The latter apparently arises because much of the area irrigated now was earlier in controlled drainage schemes.

Table 17 provides a more detailed analysis of the intended area-impact of irrigation, where:

$$\text{Main season area-impact} \equiv \frac{\sum_{i=1}^{n} (\text{intended scheme area})_i}{\sum_{i=1}^{n} (\text{pre-project area})} \times 100, \text{ and}$$

$$\text{Both season area-impact} \equiv \frac{\sum_{i=1}^{n} \left(\text{Main season intended scheme area} + \text{dry season intended scheme area} \right)_i}{\sum_{i=1}^{n} (\text{pre-project area})_i} \times 100,$$

for i = 1, 2, ..., n, the number of schemes under consideration.
The dry season area-impact is the difference between the both season and main season area-impact.

This analysis shows an intended main season area-impact of 55%,[39] i.e., irrigation is intended to extend the cultivated land area by 55%. The both season area-impact of 135% suggests that irrigation is intended to increase the planted area by 135%, or in other words bring under double-cropping an area equivalent to 80% of the pre-project cultivated area. Gravity and controlled drainage schemes have about equal intended main season area-impacts (73-76%) which are substantially greater than that for pumping schemes (31%). The dry season impact of controlled drainage is only 2%, whereas for the pumping and gravity schemes the dry season impact is roughly 85 to 90%. For both seasons, gravity irrigation is expected to increase the planted area by 164%, whereas for pumping schemes the increase is only 115%.

The analysis of originally intended and 1971-72 actual cropping intensities involves definitions as follows:

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[39] Why this figure is not nearer to the corresponding figure for 1975, as reported in Table 16, is not clear.

$$\text{Originally intended cropping intensity} \equiv \frac{\sum_{i=1}^{n} \left(\text{originally intended main season area} + \text{originally intended dry season area}\right)_i}{\sum_{i=1}^{n} \left(\text{originally intended main season area}\right)_i} \times 100, \text{ and}$$

$$\text{Actual 1971-72 cropping intensity} \equiv \frac{\sum_{i=1}^{n} \left(\text{actual main season area in 1971-72} + \text{actual dry season area in 1971-72}\right)_i}{\sum_{i=1}^{n} \left(\text{originally intended main season area}\right)_i} \times 100$$

The originally intended cropping intensity for the 552 small and medium scale D.I.D. irrigation schemes[40] is 152%, thereby implying that just over one-half the planned scheme area is intended for double-cropping (Table 18). The intended cropping intensities in the West Central and Southwest Regions are considerably higher than those elsewhere. Among irrigation-types, the originally intended cropping intensity for pumping schemes (165%) slightly exceeds that for gravity schemes (154%), and of course, is much more than for the controlled drainage schemes that are intended to be single-cropped (102% cropping intensity).

The actual cropping intensity in 1971-72 for all irrigation-types was considerably less than that intended, viz., 111% rather than 152%. More

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[40] Our discussion does not take into account the 4 largest schemes, mainly because dry season cropping in the Muda and Kemubu Schemes was still in active transition in 1972.

than 90% of the intended cropping intensity was achieved in the Northwest and Northeast Regions, and in Penang. At the other extreme, only about one-half the intended target was realized in the Southwest Region.

The actual cropping intensity for pump irrigation in 1971- was 141%, or about 85% of the intended target. The gravity-schemes, on the average, were only single-cropped, thus implying an achievement of only 65.6% of the intended intensity. The rate of achievement on the controlled drainage schemes was slightly lower than this (62.8%).

Actual cropping intensities can be less than intended for one or both of two reasons, viz., the planned scheme area is not fully planted during the main season, or the intended double-cropped area is cropped during the main season, but not during the dry season. We have just begun to probe into the low cropping intensity problem using this line of thinking. The data most readily available on actual cropped area and planned schemes area are for 1974-75. The ratio of actual cropped area to the planned scheme area indicates (inversely) the extent of shortfall in cropping during the main season.

For the small and medium scale D.I.D. schemes, only 75% of the planned scheme area was actually planted during the main season (Table 19).[41] A rate of 25% fallow land, where irrigation facilities have been provided,

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[41]For all D.I.D. irrigation schemes, the percent of intended scheme area actually cropped during the main season has been between 85 and 90% during the past 10 years.

is of definite concern.[42] If land use during the 1971-72 and 1974-75 crop years were similar (we hypothesize this for the purpose of discussion), this finding would imply that about 36% (111% minus 75%) of the area cropped during the main season was also cropped during the dry season. If so, we could conclude that the main season fallowing is a more important cause of cropping intensity shortfalls than is the failure to plant a second crop on land cropped during the main season. The purpose of this discussion is not to assert the validity of this finding substantively, but to suggest a possible approach in analysis that could be built upon in future research aimed at exploring more precisely the nature of the critical problem of low utilization of irrigation facilities, especially in Malaysia's smaller irrigation schemes.

Irrigation scheme yields

The possibility of relatively full water control with pumping schemes and relatively little water control with controlled drainage schemes, and the implications of varying degrees of water control on the expected

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[42]The reluctance of paddy farmers to stress heavily paddy cultivation in most parts of Malaysia (Muda and Tanjong Karang being general exceptions) is generally known. A recent study by Lim (1979) documents the low profitability of paddy farming, on the one hand, and relatively more remunerative off-farm employment opportunities, on the other, as main reasons why the actual cropping intensity in Malacca's Bachang Irrigation Scheme during the past three years has been 154% rather than the intended 200%.

average level and stability of yields over time, have already been pointed out. The earlier discussion included attention to a time series analysis of 10 sample schemes of each irrigation-type in Pahang.

This analysis involves a much larger number of schemes (viz., 552), but only cross-sectional comparisons (Table 20). Our criterion for comparison is yield per ha.

During the main season, the average yield was 2.36 t/ha, with gravity scheme yields 8% above-average, pumping schemes only 2% above average, and controlled drainage schemes only 58% of the average. The same relative relationships among irrigation-types emerged with the earlier Pahang State analysis.

Dry season yields in 1971-72 in pumping schemes were 8% higher than in gravity schemes, thus conforming to expectations. The dry season yields were only 3% more than main season yields,[43] however, thus suggesting that the usually more favored cloud-cover conditions of the dry season either did not obtain or were not able to exercise much effect on yield.

Table 21 shows the mean paddy yields in different states and regions. The yields are highest in Penang State, perhaps reflecting its long experience with intensive double-cropping, and lowest on the East Coast,

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[43]For wet paddy throughout Peninsular Malaysia, dry season yields during the past 10 years have been 10-25% higher than wet season yields. From 10-20 years ago the yields from the 2 seasons were roughly the same, and prior to that dry season yields were less than wet season yields. Thus, there seems to have been a definite trend up in the yield of dry season paddy relative to wet season paddy.

especially in Kelantan and Pahang. Poor soils and unfavorable topography are undoubtedly two of the explanations for lower yields on the East Coast.

IV. RESEARCH PRIORITIES

Our scheme of research priorities is structured around the four key irrigation variables dealt with in the prior section:

- type of irrigation, i.e., pumping versus gravity versus controlled drainage;
- size of irrigation scheme, e.g., with respect to 3 to 6 different scales of scheme size;
- irrigation region, e.g., the 6 regions outlined above;
- irrigation intensification (i.e., irrigation investments to improve existing cultivated land) versus irrigation extensification (i.e., irrigation investments to extend cultivation into new areas).

We believe that the most important longer-term irrigation development options for Malaysia can be subsumed under one of these categories. Understanding prior experience with respect to the stated (illustrative) conditions for each key variable, as through social science research, should be able to provide insights to better inform decisions on relative emphases to be given in future irrigation policies.

Examples of research questions that might be explored for various options (different conditions) for each key variable and/or among various combinations of the variables include the following:

1. What changes have there been over time in the relative levels of investments?

2. What changes have there been over time in the "real" construction costs per unit of area developed?

3. What differences are there now in intended versus actual cropping intensities and do these differences arise because of unplanned fallow land during the main season and/or unexpectedly low rates of double-cropping (intensification versus extensification is of lower priority)?

4. What difference are there in average levels and stabilities of yields over time (especially for type of irrigation and irrigation region)?

5. What have been the rates of return to investment in irrigation?

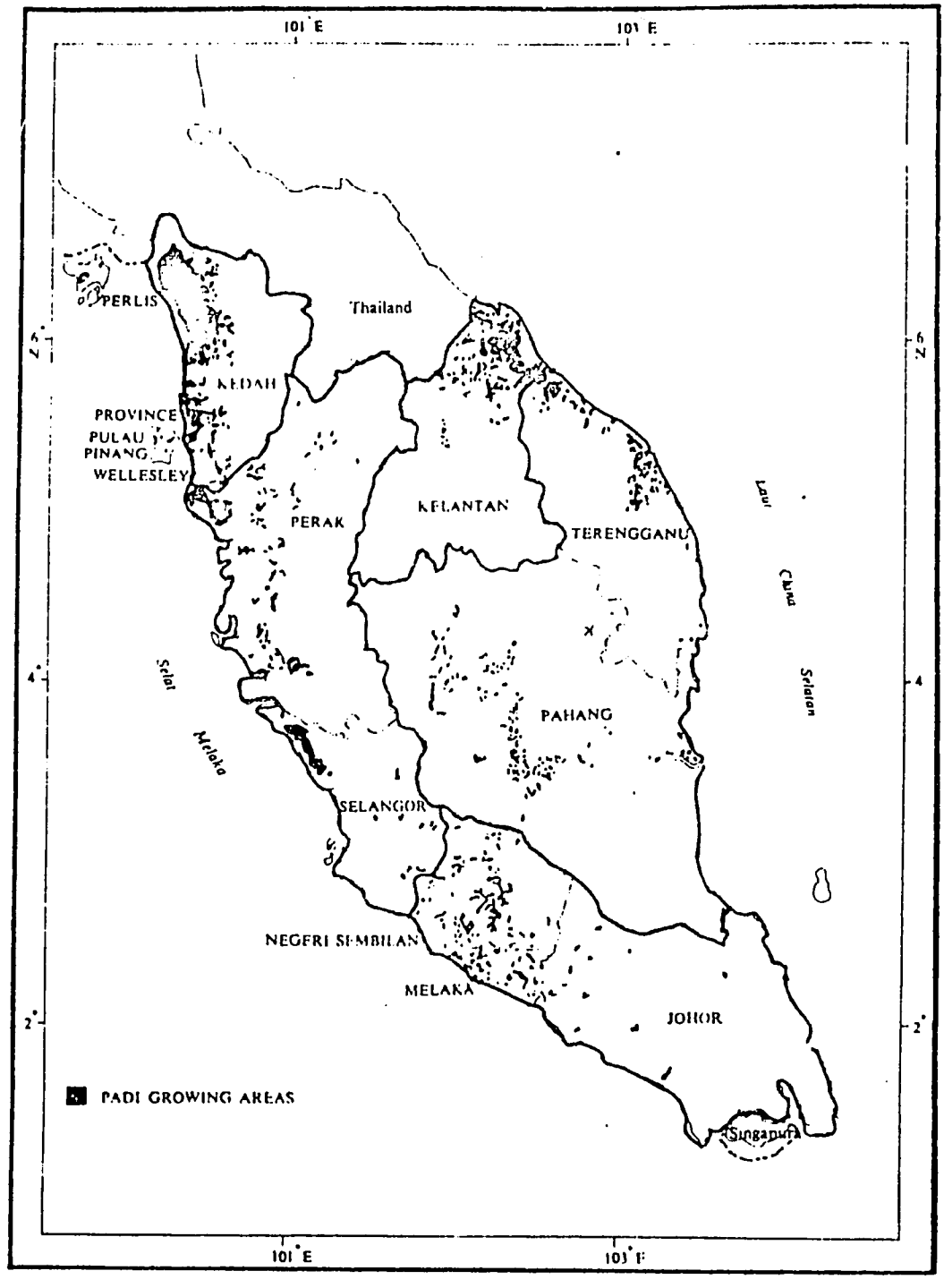
6. What differences are there in the equity of water distribution among irrigators, and in the distribution of benefits from irrigation?

It is envisioned that the first 4 questions could be further explored with secondary data sources, but that ultimately case studies to explore special dimensions of these questions would be required. To explore the last two questions would require primary data collection through field surveys.

This list may be too unfocussed to be of much help. After discussing the list with Drainage and Irrigation Department personnel we hope to refine and make more specific our listing of relative research priorities.

Proposed irrigation regions:

Northwest: Perlis, Kedah
West Central: Penang, Perak, Selangor
Southwest: Negeri Sembilan, Malacca, Johore
East Central: Pahang, Trengganu
Northeast: Kelantan



Source: Wong (1971, 52)

Fig.1. Paddy Growing Areas in Peninsular Malaysia.

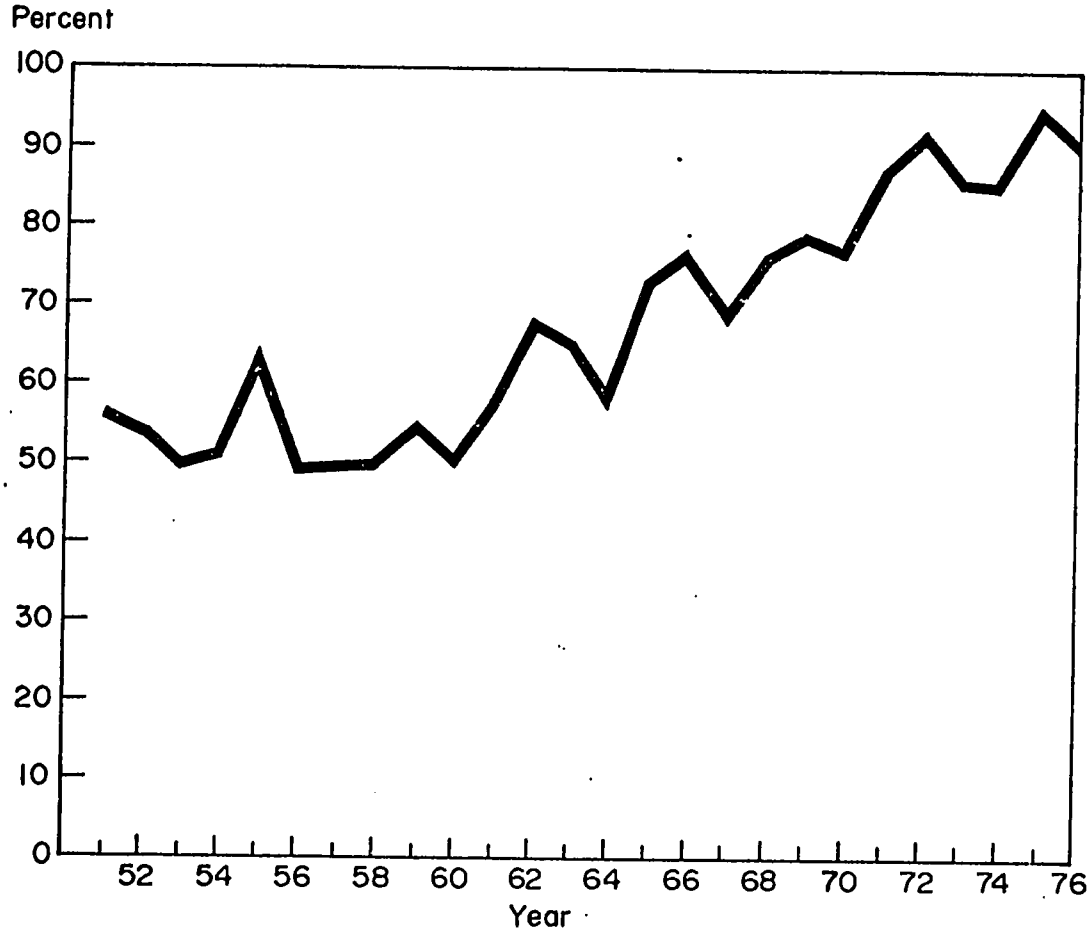
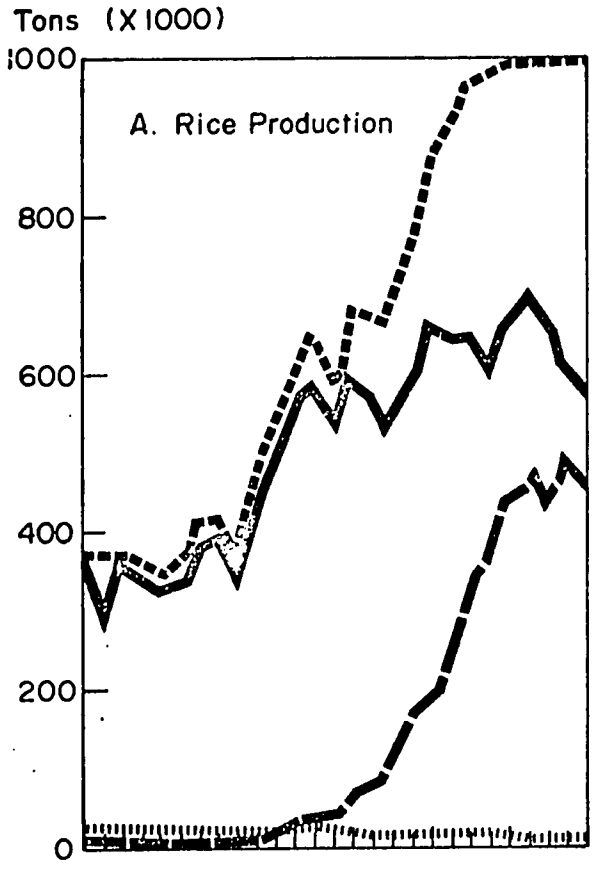
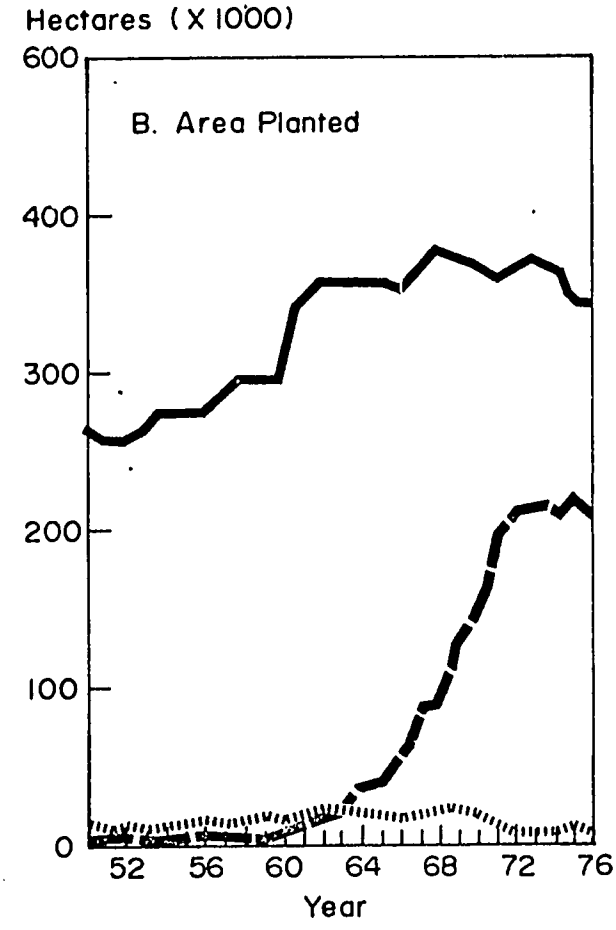
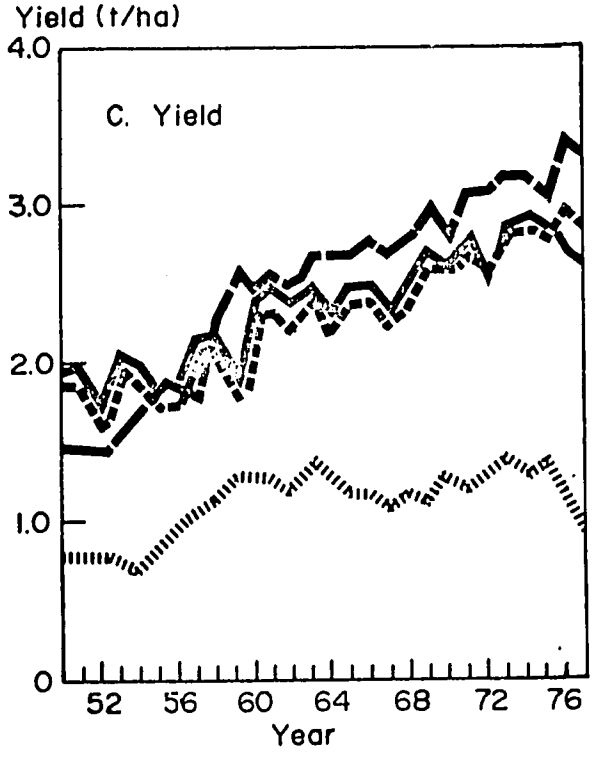


Fig. 2. Percent rice self-sufficiency, Peninsular Malaysia, 1950/51-1975/76.







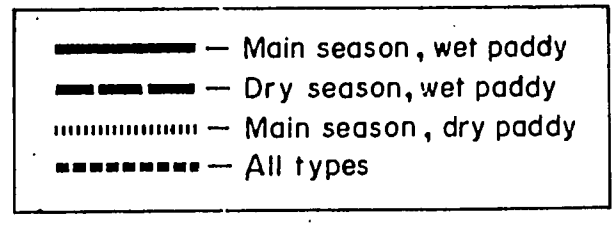


Fig. 3. Rice production, area planted and yield by type of paddy, Peninsular Malaysia, 1950/51 - 1976/77.

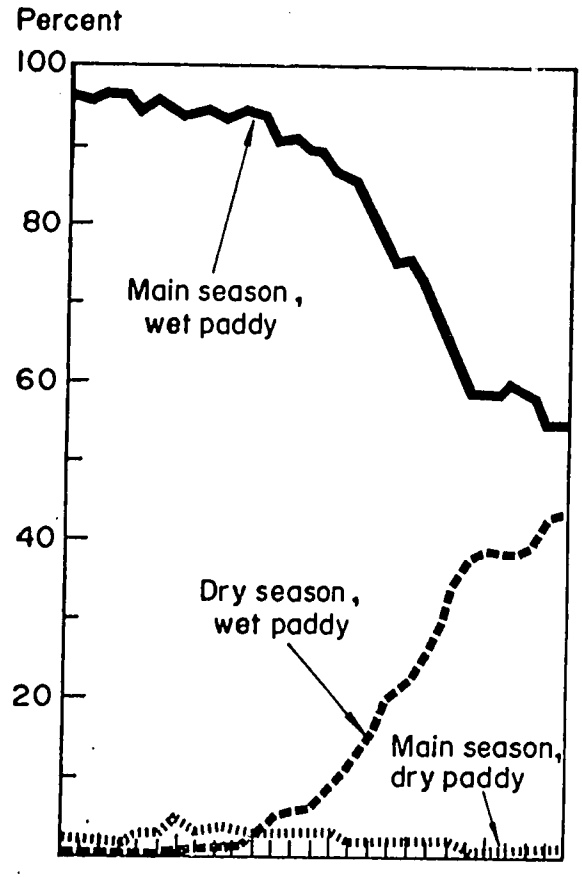


Fig. 4. Relative importance of different types of paddy production, Peninsular Malaysia, 1950/51 — 1976/77.

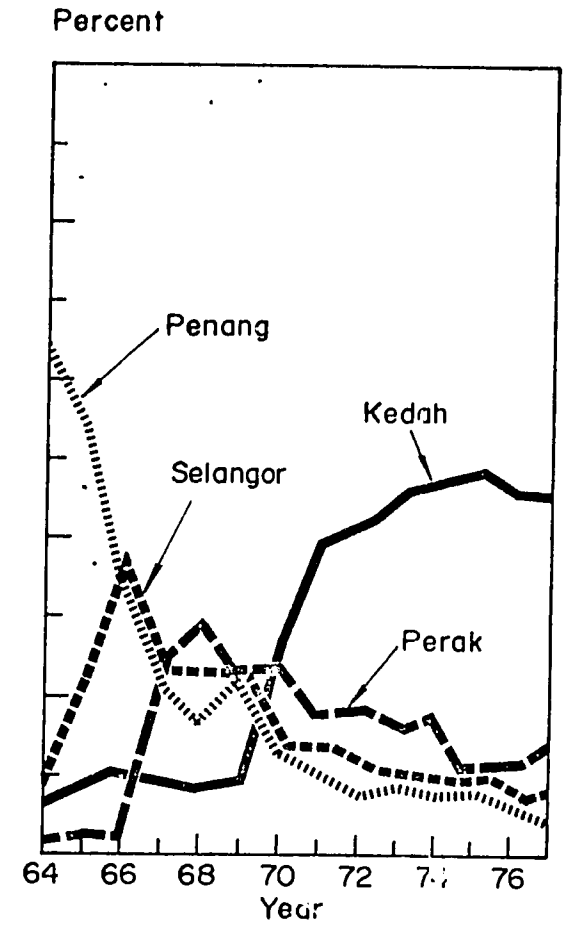


Fig. 5. Dry season paddy production, percent accounted for by selected states, Peninsular Malaysia, 1963/64 – 1976/77.

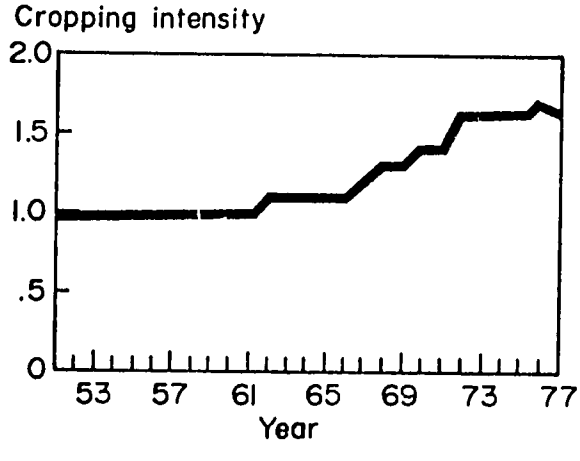


Fig. 6. Cropping intensity, wet land, Peninsular Malaysia, 1950/51 – 1976/77.

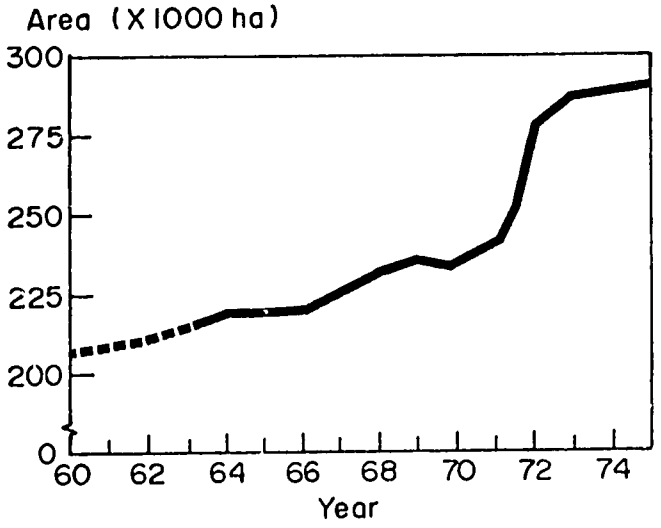


Fig. 7. Area of DID irrigated land, Peninsular Malaysia, 1959/60 - 1974/75.

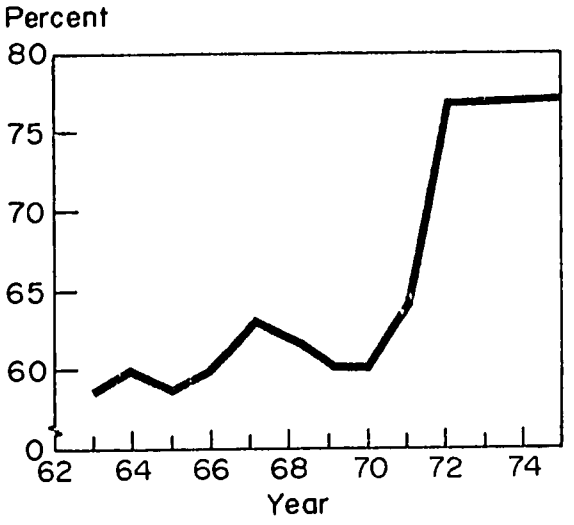


Fig. 8. Percent irrigable area, Peninsular Malaysia, 1962/63 - 1974/75.

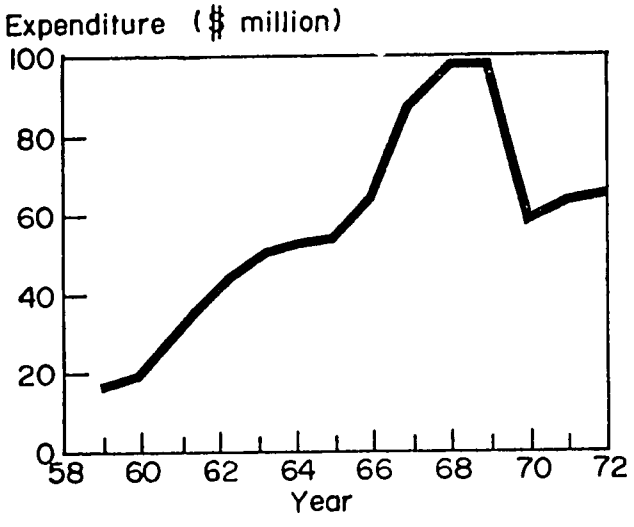


Fig. 9. Drainage and Irrigation Department "Real" annual expenditure (1960 prices), Peninsular Malaysi, 1959 – 1972.

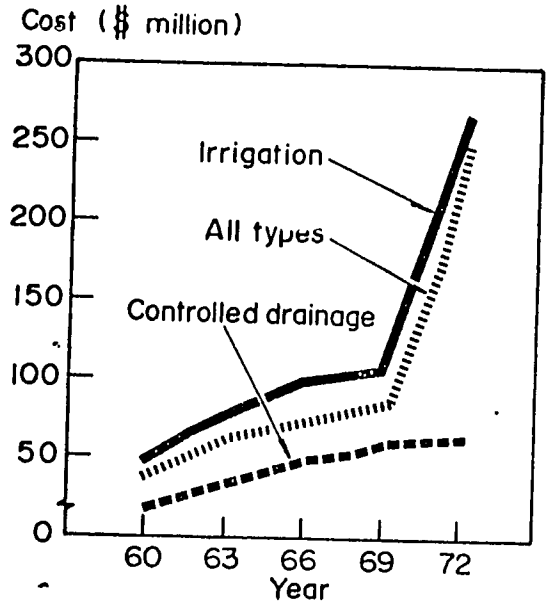


Fig. 10. DID Irrigation Schemes, cumulative per hectare "Real" capital construction costs (1960 prices), Peninsular Malaysia, 1960 – 1972.

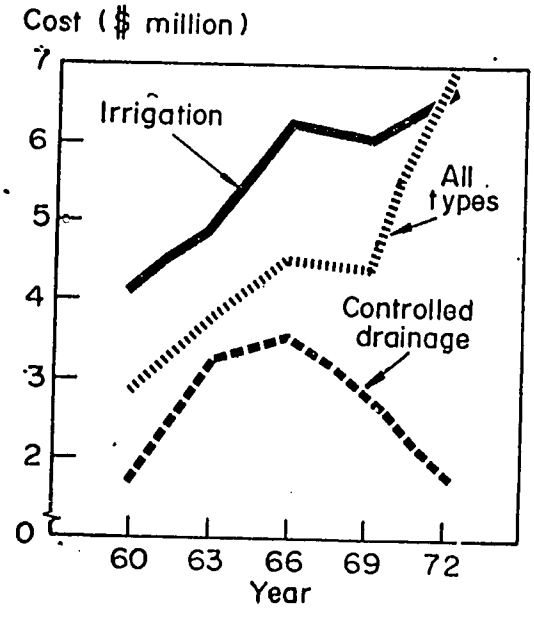
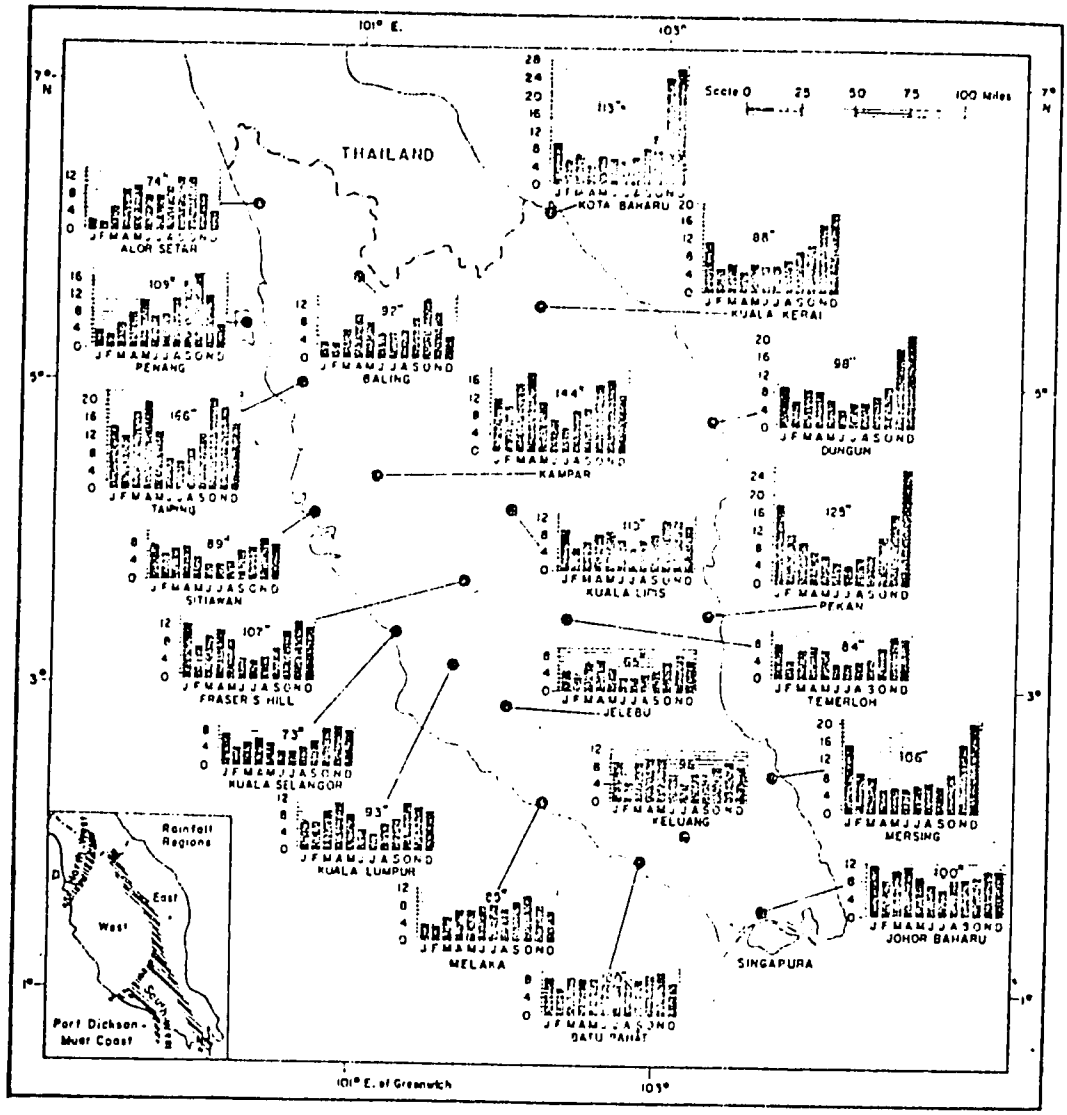


Fig. 11. DID Irrigation Schemes, per hectare "Real" annual maintenance costs (1960 prices), Peninsular Malaysia, 1960 – 1972.



Source: Wong, (1976, 11)

Fig. 12. Average Monthly Rainfall Distribution and Average Annual Rainfall of Selected Rainfall Stations in Peninsular Malaysia.

Table 1. Total paddy production, all types of paddy, by state (region), Malaysia, 1975-76.

State (Region)	Metric tons	Percent
Northwest	(626,250)	(52.7)
Perlis	102,340	8.6
Kedah, including the Muda scheme	523,910	44.1
West Central	(275,530)	(23.2)
Penang	65,830	5.5
Perak	127,620	10.8
Selangor	82,080	6.9
Northeast	(121,020)	(10.2)
Kelantan	121,020	10.2
East Central	(65,430)	(5.5)
Trengganu	40,150	3.4
Pahang	25,280	2.1
Southwest	(47,340)	(4.0)
N. Sembilan	18,150	1.5
Malacca	18,910	1.6
Johore	10,280	0.9
Peninsular Malaysia sub-total	1,135,570	95.6
East Malaysia	(51,652)	(4.4)
Sabah	38,931	3.3
Sarawak[a]	12,721	1.1
Total	1,187,222	100.0

[a]Data for Sarawak in 1975-76 were unavailable to the authors. They have therefore used the 1977-78 data which were available to them.

Sources: M.A. (1978a); D.I.D., Sabah (1976) and D.I.D., Sarawak (1978).

Table 2. Compound annual growth rates (%), by type of paddy, Peninsular Malaysia, 1950-51 to 1976-77.[a]

	1950-51 to 1960-61	1962-63 to 1976-77	1950-51 to 1976-77
All types of paddy			
Production	4.0 (62)	5.2 (89)	6.2 (95)
Area	1.5 (89)	3.3 (89)	4.1 (93)
Yield	2.4 (41)	1.8 (79)	2.0 (85)
Dry season, wet paddy			
Production	17.7 (59)	22.1 (92)	29.7 (95)
Area	9.4 (43)	20.0 (90)	25.4 (94)
Yield	7.6 (70)	1.8 (91)	3.4 (78)
Main season, wet paddy			
Production	3.7 (38)	1.0 (27)	3.2 (81)
Area	1.3 (80)	0.1 (1)	1.5 (77)
Yield	2.4 (40)	1.0 (46)	1.6 (74)
Mean season, dry paddy			
Production	10.6 (63)	-8.1 (81)	0.4 (0.4)
Area	3.7 (51)	-7.8 (76)	-1.0 (7)
Yield	6.6 (66)	-0.3 (2)	1.4 (29)

[a]The R^2s for the regressions from which the compound annual growth rates were computed are shown in brackets.

Note: For comparative purposes, we note the findings of others who have studied the sources of growth in Peninsular Malaysian paddy production:

- Bhati (1973, 25) using 1952 to 1971 data on all types of paddy production found a 4.3% annual growth rate in total production, and growth rates of 2.4% in area, and 1.9% in yield.

- Herdt, Te, and Barker (1977, Appendix Table 1) report on a study by Yim Kong Ming covering 1965-73, in which Yim found an annual compound growth rate in total production of 5.7%, and growth rates of 3.7% in irrigated area, 0.3% in unirrigated area, -0.2% in upland area, 1.4% in fertilizer as a contributor to yield, a residual of 0.5%.

Table 3. Five-Year Plan Drainage and Irrigation Department expenditures and areas planned for irrigation and drainage development, 1950-55 to 1975-80.[a]

Plan period	Total budgeted public development expenditure			Areas planned for development ('000 ha)[b]				
	Agricultural and rural development (M$ million)	Drainage and irrigation		Paddy land			Drainage	
		M$ million	% of agric and rural development	Main season		Off-season	Improvement	Extension
				Improvement	Extension			
1st Econ Plan (1950-55)	n/a	51.4	n/a	69	42	0	46	(6 projects)
1st Malaya Plan (1956-60)	n/a	63.9	n/a	87	3	0	52	4
2nd Malaya Plan (1961-65)	n/a	124.3	n/a	78	9	43	85	.....
1st Malaysia Plan (1966-70)	1,114.1	342.6	30.8	101	0.3	145	78	44
2nd Malaysia Plan (1971-75)	1,920.9	256.5	13.4	150	6	144	 84	.....
3rd Malaysia Plan (1976-80)	4,735.5	621.0	13.1	..... 97		38	226	.....

Sources: D.I.D. (1970-72), T.M.P. (1976), personal communication, Development and Planning Division, Ministry of Agriculture.

[a]The data in this table are based on information reported in narrative form and personal discussion. They should be interpreted as representing rough orders of magnitude only.

[b]Areas not completed in prior plans were usually carried over to subsequent plans. To the extent that plans did not materialize, then, there is double-counting within the respective columns of data.

Table 4. Drainage and Irrigation Department annual expenditures (M$), Peninsular Malaysia, 1959-1972.

Year	Current prices	Real prices (1959 base)
1959	16,142,161	16,142,161
1960	20,095,522	20,135,794
1961	30,601,242	30,724,139
1962	43,174,455	43,304,368
1963	50,781,117	49,397,974
1964	53,706,849	52,448,095
1965	55,425,582	54,179,455
1966	68,702,568	66,251,271
1967	96,247,838	89,118,369
1968	117,498,268	108,996,538
1969	117,400,258	109,311,227
1970	63,946,493	58,452,005
1971	68,377,056	61,545,505
1972	74,437,838	64,897,854

Table 5. D.I.D. irrigation schemes, cumulative total "real" capital construction costs (1960 prices), Peninsular Malaysia, 1969-1972.

Year	Irrigation (M$ million)	Controlled drainage (M$ million)	Ratio of irrigation to controlled drainage	Total[a] (M$ million)
1960	32.4	1.6	20	57.7
1963	61.2	3.1	20	86.2
1966	79.6	4.0	20	109.4
1969	102.2	5.4	19	131.8
1972	361.5	6.2	58	374.2

[a]The total exceeds the sum of "irrigation" and "controlled drainage," because of the existence of a third "ill-defined" category called "sub-standard/under construction."

Table 6. D.I.D. irrigation schemes, cumulative total "real" capital construction costs (1960 prices), by state (region), Peninsular Malaysia, 1972.

State (Region)	M$ ('000)	Percent
Northwest	(197,871)	(52.9)
Muda	187,731	50.2
Kedah	8,281	2.2
Perlis	1,859	0.5
Northeast	(71,583)	(19.2)
Kemubu	56,770	15.2
Kelantan	14,813	4.0
West Central	(65,534)	(17.5)
Perak	42,987	11.5
Selangor	12,871	3.4
Penang	9,676	2.6
East Central	(21,709)	(5.7)
Pahang	12,532	3.3
Trengganu	9,177	2.4
Southwest	(17,508)	(4.7)
N. Sembilan	11,145	3.0
Malacca	3,731	1.0
Johore	2,632	0.7
Total	374,205	100.0

Table 7. D.I.D. irrigation schemes, "real" annual maintenance costs (1960 prices), Peninsular Malaysia, 1960-1972.

Year	Irrigation (M$ million)	Controlled drainage (M$ million)	Ratio of irrigation to controlled drainage	Total (M$ million)
1960	2.69	0.14	19	3.90
1963	3.78	0.28	14	4.75
1966	5.03	0.29	17	6.40
1969	5.50	0.27	20	6.72
1972	9.70	0.19	51	10.80

Table 8. D.I.D. irrigation schemes, total area, by type of irrigation, Malaysia, 1972.

Type of irrigation	Number		Total area		Average area per scheme (ha)
	No.	%	Hectares	%	
Gravity	303	54.5	217,756	72.6	719
Pumping	107	19.2	65,806	21.9	615
Controlled drainage	146	26.3	16,473	5.5	113
Total	556	100.0	300,035	100.0	540

Table 9. D.I.D. irrigation schemes; number, area, and production; by size-class (ha); Malaysia; 1971-72.

Size-class	Number		Area		Production of paddy	
	No.	%	Hectares	%	Tons	%
0 - 50	197	35.4	6,081	2.0	n/a	n/a
51 - 100	114	20.5	8,281	2.8	n/a	n/a
101 - 200	123	22.1	17,420	5.8	n/a	n/a
201 - 300	38	6.8	8,936	3.0	n/a	n/a
301 - 400	19	3.4	6,418	2.1	n/a	n/a
401 - 500	12	2.2	5,202	1.7	n/a	n/a
Sub-total	(503)	(90.4)	(52,338)	(17.4)	(103,254)	(7.9)
501 - 600	9	1.6	4,893	1.6	6,687	0.5
601 - 700	3	0.6	1,937	0.7	5,416	0.4
701 - 800	2	0.4	1,495	0.5	7,949	0.6
801 - 900	7	1.3	5,857	1.9	16,075	1.2
901 - 1,000	1	0.2	972	0.3	3,175	0.3
Sub-total	(22)	(4.1)	(15,154)	(5.0)	(142,556)	(3.0)
1,000 - 2,000	14	2.5	20,873	7.0	60,274	4.6
2,001 - 4,000	10	1.8	27,066	9.0	73,986	5.7
4,001 - 10,000	3	0.5	23,886	8.0	78,296	6.0
10,000	4	0.7	160,718	53.6	950,964	72.8
Sub-total	(31)	(5.5)	(232,543)	(77.6)	(1,163,520)	(89.1)
Total	556	100.0	300,035	100.0	1,306,076	100.0

Table 10. D.I.D. irrigation schemes, total area, by type of irrigation, and by state (region), Malaysia, 1972.[a]

State (Region)	Pumping		Gravity		Controlled drainage		Total
	Hectares	%	Hectares	%	Hectares	%	Hectares
Northwest	(2,68,)	(2.3)	(112,877)	(96.5)	(1,454)	(1.2)	(117,018)
Perlis	0	0	6,964	100.0	0	0	6,964
Kedah[b]	2,687	2.4	105,913	96.3	1.454	1.3	110.054
West Central	(13,458)	(15.9)	(70,700)	(83.8)	(244)	(0.3)	(84,402)
Penang	8,762	58.2	6,038	40.2	244	1.6	15,044
Perak	4,696	9.8	43,287	90.2	0	0	47,983
Selangor	0	0	21,375	100.0	0	0	21,375
Northeast	(30,275)	(94.9)	(1,630)	(5.1)	(0)	(0)	(31,905)
Kelantan	30,275	94.9	1,630	5.1	0	0	31,905
East Central	(7,504)	(26.7)	(6,228)	(22.1)	(14,385)	(51.2)	(28,117)
Trengganu	5,039	45.9	2,957	26.9	2,992	27.2	10,988
Pahang	2,465	14.4	3,271	19.1	11,393	66.5	17,129
Southwest	(6,787)	(28.9)	(16,335)	(69.5)	(390)	(1.6)	(23,512)
N. Sembilan	3,780	36.3	6,619	63.7	0	0	10,399
Malacca	2,146	25.5	6,032	71.7	234	2.8	8,412
Johore	861	18.3	3,684	78.4	156	3.3	4,701
Peninsular sub-total	60,711	21.3	207,770	72.9	16,473	5.8	284,954
East Malaysia	(5,095)	(33.8)	(9,986)	(66.2)	(0)	(0)	(15,081)
Sabah	4,751	32.6	9,844	67.4	0	0	14,595
Sarawak	344	70.8	142	29.2	0	0	486
Total	65,806	21.9	217,756	72.6	16,473	5.5	300,035

[a]The percents in the table are with respect to row totals.
[b]The Muda scheme is included in this table under Kedah, even though part of the scheme is in Perlis.

Table 11. D.I.D. irrigation schemes, mean planned area (ha) per scheme, by type of irrigation and by state (region), Malaysia, 1972.

State (Region)	Pumping	Gravity	Controlled drainage	Average
Northwest				
Perlis	n/a	580	n/a	580
Kedah[e]	672	7,565[a]	1,453	5,792
Northeast				
Kelantan	5,046[b]	204	n/a	2,279
West Central				
Penang	1,460	863	244	1,075
Perak	671	1,056[c]	n/a	1,000
Selangor	n/a	929[d]	n/a	929
Southwest				
N. Sembilan	105	91	n/a	95
Malacca	429	208	117	234
Johore	123	307	156	235
East Central				
Trengganu	504	296	374	392
Pahang	190	59	86	85
East Malaysia				
Sabah	432	547	n/a	503
Sarawak	172	142	n/a	162
Average	615	719	113	504

[a]The mean area of the 13 gravity schemes other than the 101,215 ha Muda scheme in Kedah is 361 ha per scheme.

[b]The mean area of the 5 pumping schemes other than the 16,194 ha Kemubu scheme in Kelantan is 2,816 ha per scheme.

[c]The mean area of the 40 gravity schemes other than the 23,453 ha Krian scheme in Perak is 496 ha per scheme.

[d]The mean area of the 22 gravity schemes other than the 19,856 ha Tanjong Karang scheme in Selangor is 69 ha per scheme.

[e]The Muda scheme is included in this table under Kedah, even though part of the scheme is in Perlis.

Table 12. D.I.D. irrigation schemes, mean construction and maintenance costs, by type of irrigation, 1972.

Type of irrigation	Construction				Maintenance			
	All schemes		Schemes ≤ 10,00 ha		All schemes		Schemes ≤ 10,000 ha	
	M$/ha	Ratio to national average	M$/ha	Ratio to overall average	M$/ha	Ratio to national average	M$/ha	Ratio to overall average
Pumping	1,658	1.18	1,073	1.35	60	1.36	59	1.31
Gravity	1,104	0.78	700	0.88	42	0.95	43	0.95
Controlled drainage	387	0.27	387	0.49	13	0.30	13	0.28
Average	1,410	1.00	796	1.00	44	1.00	45	1.00

Table 13. Performance of selected D.I.D. pumping, gravity and controlled drainage schemes, Pahang State, main season, Malaysia, 1959-60 to 1974-75.

	Pumping	Gravity	Controlled drainage
Mean yield (t/ha)	1.42	1.85	1.00
Coefficient of variation of yield (No. of observations)			
0 - 25	4	7	1
26 - 50	2	1	6
51 - 75	2	1	3
76 -100	1	0	0
>100	1	1	0
Mean cropped area as a % of planned scheme area (No. of observations)			
0 - 25	2	1	0
26 - 50	4	2	0
51 - 75	3	4	4
75 -100	1	3	6
Coefficient of variation of area (No. of observations)			
0 - 25	2	3	4
26 - 50	3	5	5
51 - 75	2	1	1
76 -100	2	1	0
>100	1	0	0

Table 14. D.I.D. irrigation schemes, mean construction and maintenance costs (M$/ha) by type and size-class (ha) of irrigation schemes, Malaysia, 1972.

Size-class	Construction			Maintenance		
	Pumping	Gravity	Controlled drainage	Pumping	Gravity	Controlled drainage
0 - 50	1,706	1,318	771	92	72	15
51 - 100	1,492	1,021	462	85	50	10
101 - 200	1,087	723	314	72	50	11
201 - 300	1,864	693	355	67	41	16
301 - 400	1,351	699	491	67	46	11
401 - 500	763	201	n/a	43	26	n/a
501 - 600	792	758	805	35	53	9
601 - 700	84	494	n/a	33	47	n/a
701 - 800	n/a	1,127	n/a	n/a	61	n/a
801 - 900	1,621	608	n/a	73	38	n/a
901 - 1000	1,244	n/a	n/a	88	n/a	n/a
1001 - 2000	842	429	170	71	30	17
2001 - 4000	1,213	814	n/a	59	38	n/a
4001 - 10,000	1,003	364	n/a	46	44	n/a
>10,000[a]	4,028	1,712	n/a	63	41	n/a
Mean (≤10,000 ha)	1,074	700	387	59	43	13
Mean (all)	1,658	1,658	387	60	42	13

[a]This category of largest irrigation schemes includes the large and only relatively recently completed (and hence, involving an investment of lower-valued dollars) Kemubu pumping scheme with a construction cost of M$4,029/ha and Muda gravity scheme with a construction cost of M$2,132/ha.

Table 15. D.I.D. small and medium scale irrigation schemes, mean construction and maintenance costs (M$/ha), by type of irrigation and by state (region), Malaysia, 1972.[a]

State (Region)	Construction cost				Maintenance cost			
	Pumping	Gravity	Controlled drainage	Average	Pumping	Gravity	Controlled drainage	Average
Northwest								
Perlis	n/a	198	n/a	198	n/a	15	n/a	15
Kedah	1,229	656	189	753	76	45	27	52
West Central								
Penang	680	661	481	669	57	61	64	59
Perak	1,518	939	n/a	1,050	69	48	n/a	52
Selangor	n/a	750	n/a	750	n/a	49	n/a	49
Southwest								
N. Sembilan	1,405	993	n/a	1,143	39	42	n/a	41
Malacca	262	536	337	460	46	34	20	37
Johore	1,196	442	172	572	76	33	48	41
East Central								
Trengganu	1,208	937	193	858	51	23	9	32
Pahang	1,560	1,211	465	765	88	64	10	32
Northeast								
Kelantan	1,055	359	n/a	983	50	29	n/a	48
East Malaysia								
Sabah	980	406	n/a	593	81	49	n/a	59
Sarawak	1,538	2,011	n/a	1,676	34	46	n/a	37
Average	1,073	700	387	796	59	43	13	45

[a]These data do not take into account the 4 largest irrigation schemes in Malaysia whose construction and maintenance costs (M$/ha), respectively, are as follows: Muda gravity - 2,132 and 48; Krian gravity - 841 and 32; Tanjong Karang gravity - 601, 19; and Kemubu pumping - 4,028,63.

Table 16. D.I.D. irrigation schemes, pre-project and post-project areas, by state (region), Peninsular Malaysia, 1975.

State (Region)	Pre-project area (ha)	Post-project area (ha)	Percent added area[a]
Northwest	(88,205)	(119,568)	(35.6)
Perlis	6,796	7,368	8.4
Kedah	8,737	10,985	25.7
Muda Scheme	72,672	101,215	39.3
West Central	(36,386)	(86,458)	(137.6)
Penang	13,564	15,261	12.5
Perak	9,916	26,357	165.8
Krian Scheme	11,846	23,453	98.0
Selangor	980	19,856	1926.1
Tanjong Karang Scheme	80	1,531	1813.8
Southwest	(15,628)	(23,898)	(52.9)
N. Sembilan	7,839	10,589	35.1
Malacca	5,472	8,764	60.2
Johore	2,317	4,545	96.2
East Central	(17,653)	(31,190)	(76.7)
Trengganu	10,265	12,595	22.7
Pahang	7,388	18,595	151.7
Northeast	(19,508)	(33,913)	(73.8)
Kelantan	14,650	14,885	1.6
Kemubu Scheme	4,858	19,028	291.7
Total	177,380	295,027	66.3

[a]This is the difference between the pre-project and post-project areas, expressed as a percent of the pre-project area.

Table 17. D.I.D. small and medium scale irrigation schemes, intended area-impact of irrigation, by type of irrigation and by state (region), Malaysia, 1972.[a]

State (Region)	Pumping		Gravity		Controlled drainage		Average	
	Main season	Both seasons	Main season	Both seasons	Main season	Both seasons	Main season	Both seasons
Northwest								
Perlis	n/a	n/a	9	9	n/a	n/a	9	9
Kedah	16	111	1	41	0	0	45	53
West Central								
Penang	10	119	10	104	113	220	11	114
Perak	100	275	213	431	n/a	n/a	182	389
Selangor	n/a	n/a	55	156	n/a	n/a	55	156
Southwest								
N. Sembilan	49	134	29	112	n/a	n/a	36	119
Malacca	42	61	67	233	48	48	59	178
Johore	65	230	105	236	54	54	94	227
East Central								
Trengganu	11	86	35	88	21	26	19	70
Pahang	550	550	181	227	125	125	159	167
Northeast								
Kelantan	0	48	17	17	n/a	n/a	2	45
East Malaysia								
Sabah	209	449	212	300	n/a	n/a	211	348
Sarawak	25	25	17	17	n/a	n/a	22	22
Average	31	115	73	164	76	78	55	135

[a]These data do not take into account the 4 largest irrigation schemes in Malaysia whose intended area impacts in the main season and for both seasons, respectively, are as follows: Muda, Northwest, gravity - 39, 134; Krian, Perak, gravity - 98, 201; Tanjong Karang, Selangor, gravity - 24,770, 49,440; and Kemubu, Kelantan, pumping - 233,483.

Table 18. D.I.D. small and medium scale irrigation schemes, originally intended and actual 1971-72 cropping intensities, by type of irrigation and by state (region), Malaysia, 1971-72.[a]

State (Region)	Pumping			Gravity			Controlled drainage			Average		
	Original	Actual	Actual as % of the original	Original	Actual	Actual as % of the original	Original	Actual	Actual as % of the original	Original	Actual	Actual as % of the original
Northwest												
Perlis	n/a	n/a	n/a	100	94	94.0	n/a	n/a	n/a	100	94	94.0
Kedah	182	172	94.5	140	136	97.1	100	100	100.0	146	141	95.6
West Central												
Penang	200	200	100.0	185	164	88.7	150	130	86.7	193	184	95.3
Perak	188	160	85.1	170	89	52.4	n/a	n/a	n/a	173	102	59.0
Selangor	n/a	n/a	n/a	168	114	67.9	n/a	n/a	n/a	168	114	67.9
Southwest												
N. Sembilan	157	76	48.4	161	85	52.8	n/a	n/a	n/a	159	81	50.9
Malacca	113	78	69.0	208	101	48.6	100	100	100.0	180	95	52.8
Johore	200	101	50.5	193	88	45.6	100	12	12.0	191	88	46.1
East Central												
Trengganu	167	143	85.6	139	110	79.1	105	80	76.2	142	117	82.4
Pahang	100	47	47.0	117	73	62.4	100	54	54.0	103	57	55.3
Northeast												
Kelantan	148	137	92.6	100	92	92.0	n/a	n/a	n/a	145	134	92.4
East Malaysia												
Sabah	178	143	80.3	128	89	69.5	n/a	n/a	n/a	144	106	73.6
Sarawak	100	64	64.0	n/a	n/a	n/a	n/a	n/a	n/a	100	64	64.0
Average	165	141	85.5	154	101	65.6	102	64	62.8	152	111	73.0

[a]These data do not take account the 4 largest irrigation schemes in Malaysia whose original and actual cropping intensities, respectively, are as follows: Muda, Northwest, gravity - 168,172; Krian, Perak, gravity - 152, 188; Tanjong Karang, Selangor, gravity - 200, 195; and Kemubu, Kelantan, gravity - 175, 180.

Table 19. D.I.D. irrigation schemes; planned scheme area versus actual cropped Area, main season, 1974-75; by state (region); Peninsular Malaysia.

State (Region)	Planned scheme area (ha)	1974-75 main season cropped area (ha)	Cropped area as a percent of scheme area
Northwest	(119,568)	(117,748)	(98.5)
Perlis	7,368	7,368	100.0
Kedah	10,985	10,380	94.5
Muda Scheme	101,215	100,000	98.8
Northeast	(33,913)	(32,427)	(95.6)
Kelantan	14,885	13,399	90.0
Kemubu Scheme	19,028	19,028	100.0
West Central	(86,458)	(71,022)	(82.2)
Penang	15,261	14,754	96.7
Perak	26,357	19,980	75.8
Krian Scheme	23,453	16,092	68.8
Selangor	1,531	832	54.4
Tanjong Karang Scheme	19,856	19,364	97.5
East Central	(31,190)	(17,857)	(57.3)
Trengganu	12,595	7,015	55.7
Pahang	18,595	10,842	58.3
Southwest	(23,897)	(13,632)	(57.0)
N. Sembilan	10,589	6,034	57.0
Malacca	8,763	5,616	64.1
Johore	4,545	1,982	43.6
Total (all)	295,026	252,686	85.7
Total ($\leq$10,000 ha)	131,474	98,202	74.7

Table 20. D.I.D. small and medium scale irrigation schemes, mean paddy yields, by type of irrigation and by season, Malaysia, 1971-72.[a]

Type of irrigation	Main season		Dry season		Ratio of dry season to main season yield
	Yield (t/ha)	Ratio to national average	Yield (t/ha)	Ratio to national average	
Pumping	2.40	1.02	2.53	1.04	1.05
Gravity	2.54	1.08	2.34	0.96	0.92
Controlled drainage	1.38	0.58	n/a[b]	n/a	n/a
Average	2.36	1.00	2.44	1.00	1.03

[a]These data do not take into account the 4 largest irrigation schemes in Malaysia whose main season and dry season yields (t/ha), respectively, are as follows: Muda gravity - 3.8, 3.9; Krian gravity - 2.8, 3.1; Tanjong Karang gravity - 3.6, 2.6; and Kemubu pumping - 0.3.0.

[b]Two of the 146 controlled drainage schemes are reported to have produced a mean yield of 2.0 t/ha during the dry season.

Table 21. D.I.D. small and medium scale irrigation schemes, mean paddy yields, by state (region) and by season, Malaysia, 1971-72.

State (Region)	Main season		Dry season	
	Yield (t/ha)	Ratio to national average	Yield (t/ha)	Ratio to national average
Northwest				
Perlis	3.09	1.31	3.21	1.32
Kedah	2.37	1.00	2.51	1.03
West Central				
Penang	3.29	1.39	3.42	1.40
Perak	2.53	1.07	2.35	0.96
Selangor	2.00	0.85	2.03	0.83
Southwest				
N. Sembilan	2.80	1.19	2.35	0.96
Malacca	2.30	0.97	2.50	1.02
Johore	2.40	1.02	2.57	1.05
East Central				
Trengganu	2.05	0.87	2.52	1.03
Pahang	1.27	0.54	2.35	0.96
Northeast				
Kelantan	1.34	0.57	n/a	n/a
East Malaysia[b]				
Sabah	2.90	1.23	2.85	1.17
Average	2.36	1.00	2.44	1.00

[a]The data do not take into account the 4 largest irrigation schemes in Malaysia whose main season and dry season yields (t/ha), respectively, are as follows: Muda, Northwest - 3.8, 3.9; Krian, Perak - 2.8, 3.1; Tanjong Karang, Selangor - 3.6, 2.6; and Kemubu, Kelantan - 0, 3.0.

[b]The 3 Sarawak systems were not cropped in 1971-72.

Table 22. D.I.D. irrigation schemes, area (acres) planted to various dry season crops, by state, Peninsular Malaysia, 1956-57 to 1971-72.

Year	Area of dry season crop other than paddy						Peninsular dry season paddy area	Percnt of Peninsular area in crops other than paddy[a]
	Perak	Selangor	Malacca	Kelantan	Trengganu	Peninsular total		
1956-57	n/a	1,135	355	0	0	1,490	8,385	15.1
1957-58	2,650	1,189	370	0	0	4,209	6,615	38.9
1958-59	1,802	1,215	410	0	0	3,427	7,260	32.1
1959-60	1,195	1,671	592	0	0	3,458	10,570	24.7
1960-61	910	2,030	438	0	0	3,378	20,195	14.3
1961-62	1,090	1,846	420	0	0	3,356	46,520	6.7
1962-63	1,885	2,240	353	76	0	4,554	49,110	8.5
1963-64	1,320	8,893	320	115	138	10,786	58,420	15.6
1964-65	660	1,230	338	157	177	2,562	89,840	2.8
1965-66[b]	850	350	313	185	309	2,067	104,450	1.9
1966-67	910	4,090	338	186	115	5,639	156,940	3.5
1967-68	874	1,270	344	762	32	3,342	224,660	1.5
1968-69	873	80	366	514	68	1,901	238,130	0.8
1969-70	979	120	364	590	0	2,053	325,930	1.6
1970-71	590	125	307	790	0	1,812	393,760	0.5
1971-72	559	140	300	730	0	1,729	487,850	0.4

[a]This column represents the Peninsular area in crops other than paddy as a percent of the total dry season planted area.

[b]Kedah also had 60 acres of maize under dry season irrigation.

Table 23. Area planted (ha), total rice production ('000 tons), and yield (ton paddy/ha); main season wet paddy, off-season wet padi, and dry padi; Peninsular Malaysia, 1950-51 to 1977-78.

Year	Main season wet paddy			Off-season wet paddy			Dry paddy			Total: All types of paddy		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
1950-51	275,733	361	2.03	3,016	3	1.53	15,247	8	0.82	726,170	372	1.95
1951-52	261,016	278	1.63	2,117	2	1.46	12,850	7	0.84	681,680	287	1.61
1952-53	262,534	362	2.12	1,385	1	1.11	13,903	7	0.77	686,220	370	2.05
1953-54	268,275	348	2.00	2,781	3	1.65	11,146	5	0.69	697,040	356	1.96
1954-55	280,976	332	1.83	4,002	5	1.93	15,421	9	0.89	741,985	346	1.78
1955-56	275,417	343	1.93	2,281	2	1.36	16,761	11	1.01	727,315	356	1.85
1956-57	280,895	394	2.15	3,395	4	1.8	18,652	19	1.56	748,265	417	2.12
1957-58	288,097	402	2.15	2,678	4	2.3	16,968	13	1.19	760,125	419	2.10
1958-59	292,016	354	1.88	2,939	5	2.62	18,198	15	1.26	773,490	374	1.83
1959-60	295,486	455	2.37	4,279	7	2.52	19,555	16	1.26	788,720	478	2.3
1960-61	299,891	495	2.54	8,176	14	2.64	16,887	14	1.28	802,635	523	2.47
1961-62	353,332	556	2.42	18,834	31	2.54	23,498	18	1.19	977,290	605	2.35
1962-63	358,773	593	2.54	19,883	35	2.72	22,449	20	1.36	990,730	648	2.49
1963-64	356,231	533	2.3	23,652	41	2.67	21,190	18	1.31	990,650	592	2.27
1964-65	363,036	595	2.52	36,372	65	2.74	21,636	17	1.21	1,039,980	677	2.47
1965-66	360,348	573	2.45	42,287	77	2.79	21,405	16	1.16	1,047,380	666	2.42
1966-67	355,834	533	2.3	63,538	112	2.72	20,850	14	1.06	1,087,350	659	2.3
1967-68	367,040	598	2.52	90,955	166	2.82	21,749	16	1.16	1,182,500	780	2.49
1968-69	382,984	663	2.67	96,409	186	2.96	23,150	17	1.14	1,241,280	867	2.64
1969-70	379,761	651	2.64	131,955	245	2.87	21,692	18	1.26	1,317,520	915	2.64
1970-71	373,215	649	2.67	159,417	324	3.14	21,045	16	1.24	1,365,110	990	2.77
1971-72	361,401	598	2.54	197,510	393	3.06	13,619	11	1.28	1,414,150	1,002	2.69
1972-73	369,482	662	2.77	212,356	434	3.14	9,927	9	1.36	1,461,660	1,106	2.87
1973-74	371,283	699	2.89	217,126	457	3.24	9,113	8	1.33	1,475,880	1,164	2.99
1974-75	372,372	656	2.72	213,320	434	3.14	9,709	9	1.36	1,470,590	1,099	2.84
1975-76	347,757	619	2.74	222,405	491	3.41	10,008	8	1.16	1,433,020	1,118	2.96
1976-77	345,146	579	2.57	212,413	458	3.31	9,478	6	0.99	1,400,580	1,043	2.84
1977-78[a]	335,215	587	2.69	103,883			7,587			1,103,310		

[a]Provisional data.

Table 24. D.I.D. irrigation schemes, number and total area (ha), by type of irrigation and by state (region), Malaysia, 1972.

State (Region)	Pumping				Gravity				Controlled drainage				Total			
	No.	%	Area	%	No.	%	Area	%	No.	%	Area	%	No.	%	Area	
Northwest	(4)	(3.7)	(2,687)	(4.1)	(26)	(8.6)	(112,877)	(51.8)	(1)	(0.7)	(1,454)	(8.8)	(31)	(5.6)	(117,018)	(39.0)
Perlis	0	n/a	0	n/a	12	4.0	6,964	3.2	0	n/a	0	n/a	12	2.2	6,964	2.3
Kedah	4	3.7	2,687	4.1	14	4.6	105,913	48.6	1	0.7	1,454	8.8	19	3.4	110,054	36.7
West Central	(13)	(12.2)	(13,458)	(20.4)	(71)	(23.4)	(70,700)	(32.5)	(1)	(0.7)	(244)	(1.5)	(85)	(15.3)	(84,402)	(28.1)
Penang	6	5.6	8,762	13.3	7	2.3	6,038	2.8	1	0.7	244	1.5	14	2.5	15,044	5.0
Perak	7	6.5	4,696	7.1	41	13.5	43,287	19.9	0	n/a	0	n/a	48	8.6	47,983	16.0
Selangor	0	n/a	0	n/a	23	7.6	21,375	9.8	0	n/a	0	n/a	23	4.2	21,375	7.1
Southwest	(48)	(44.9)	(6,787)	(10.3)	(114)	(37.7)	(16,335)	(7.5)	(3)	(2.1)	(390)	(2.3)	(165)	(29.7)	(23,512)	(7.9)
N. Sembilan	36	33.6	3,780	5.7	73	24.1	6,619	3.0	0	n/a	0	n/a	109	19.6	10,399	3.5
Malacca	5	4.7	2,146	3.3	29	9.6	6,032	2.8	2	1.4	234	1.4	36	6.5	8,412	2.8
Johore	7	6.5	861	1.3	12	4.0	3,684	1.7	1	0.7	156	0.9	20	3.6	4,701	1.6
East Central	(23)	(21.5)	(7,504)	(11.5)	(65)	(21.5)	(6,228)	(2.9)	(141)	(96.6)	(14,385)	(87.4)	(229)	(41.2)	(28,117)	(9.4)
Trengganu	10	9.4	5,039	7.7	10	3.3	2,957	1.4	8	5.5	2,992	18.2	28	5.0	10,988	3.7
Pahang	13	12.2	2,465	3.8	55	18.2	3,271	1.5	133	91.1	11,393	69.2	201	36.2	17,129	5.7
Northeast	(6)	(5.6)	(30,275)	(46.0)	(8)	(2.6)	(1,630)	(0.7)	(0)	n/a	(0)	n/a	(14)	(2.5)	(31,905)	(10.6)
Kelantan	6	5.6	30,275	46.0	8	2.6	1,630	0.7	0	n/a	0	n/a	14	2.5	31,905	10.6
Peninsular Sub total	94	87.8	60,711	92.3	284	93.7	207,770	95.4	146	100	16,473	100	524	94.3	284,954	95.0
East Malaysia	(13)	(12.2)	(5,095)	(7.7)	(19)	(6.2)	(9,986)	(4.6)	(0)	n/a	0	n/a	(32)	(5.7)	(15,081)	(5.0)
Sabah	11	10.3	4,751	7.2	18	5.9	9,844	4.5	0	n/a	0	n/a	29	5.2	14,595	4.8
Sarawak	2	1.9	344	0.5	1	0.3	142	0.1	0	n/a	0	n/a	3	0.5	486	0.2
Total	107	100.0	65,806	100.0	303	100.0	217,756	100.0	146	100.0	16,473	100.0	556	100.0	300,035	100.0

Table 25. D.I.D. small and medium scale irrigation schemes, mean paddy yields (t/ha), by state (region) and by season, Malaysia, 1971-72.[a]

State (Region)	Pumping		Gravity		Controlled[b] drainage (main season)	Average	
	Main season	Dry season	Main season	Dry season		Main season	Dry season
Northwest							
Perlis	n/a	n/a	3.1	3.2	n/a	3.1	3.2
Kedah	2.8	2.8	2.2	2.2	2.2	2.4	2.5
West Central							
Penang	3.6	3.8	2.9	2.6	2.8	3.3	3.4
Perak	2.5	2.8	2.5	2.2	2.8	2.5	2.4
Selangor	n/a	n/a	2.0	2.0	n/a	2.0	2.0
Southwest							
N. Sembilan	3.0	2.4	2.7	2.3	n/a	2.8	2.4
Malacca	2.4	2.4	2.3	2.5	2.2	2.3	2.5
Johore	2.5	2.2	2.4	2.7	1.1	2.4	2.6
East Central							
Trengganu	2.0	2.5	2.3	2.4	1.9	2.1	2.5
Pahang	2.0	n/a	2.0	2.4	0.9	1.3	2.4
Northeast							
Kelantan	1.4	n/a	0.0	n/a	n/a	1.3	n/a
East Malaysia[c]							
Sabah	3.0	3.1	2.9	2.5	n/a	2.9	2.9
Average	2.4	2.5	2.5	2.3	1.4	2.4	2.4

[a]These data do not take into account the 4 largest schemes in Malaysia whose main season and dry season yields (t/ha), respectively, are as follows: Muda, Northwest, gravity - 3.8, 3.9; Krian, Perak, gravity - 2.8, 3.1; Tanjong Karang, Selangor, gravity - 3.6, 2.6; and Kemubu, Kelantan, pumping - 0,3.0.

[b]Two of the 146 controlled drainage schemes are reported to have produced a mean yield of 2.0 t/ha during the dry season.

[c]The 3 Sarawak irrigation systems were not yet cropped as of 1971-72.

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