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IRRIGATION INVESTMENT IN TAIWAN

— An Economic Analysis of Feasibility, Priority and Repayability Criteria —

SECOND EDITION

Taipei, Taiwan, Republic of China
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IRRIGATION INVESTMENT IN TAIWAN

— An Economic Analysis of Feasibility, Priority and Repayability Criteria —

Second Edition

By

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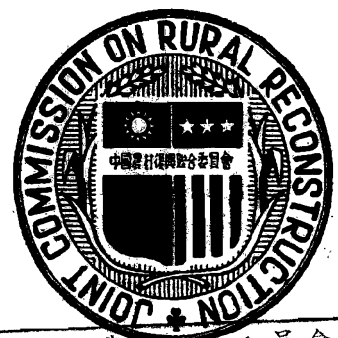

TAIPEI, TAIWAN, REPUBLIC OF CHINA

OCTOBER 1977

PREFACE

As is generally known, there has been some significant progress in agricultural development in Taiwan in the last dozen years. But as economic development goes on, we have encountered certain difficulties, among which the most important are (1) lack of a sound basis for the allocation of capital, (2) lack of a suitable institutional structure to link up savings with investment, and (3) lack of long-term financing.

Any one of these obstacles to economic development is bad enough, but lack of a sound basis for the allocation of capital can have serious effects on the disposition of industries and the balanced development of the entire economy. This, together with capital shortage and uncertain sources of capital fund, has sometimes resulted in the misallocation of scarce capital for economic development.

In view of the importance of developing criteria for the effiicient allocation of capital in Taiwan, the Sino-American Joint Commission on Rural Reconstruction (JCRR) has taken a keen interest in this problem and made, over the years, some economic evaluation of its projects to find a proper solution for it. But as the problem has wide-ranging ramifications and any study of it must take into account the generation and financing of capital fund as well as its allocation, it has been necessary for JCRR to call upon the services of experienced experts in making this study.

For this purpose, the Rural Economics Division of JCRR, of which I was then chief, initiated in 1959 a series of study projects on irrigation investment. Funds were granted to the irrigation economists group of the Provincial Water Conservancy Bureau to carry out field surveys and studies. The first study was made on problems relating to water-fee collection and the financial status of various irrigation associations in Taiwan. As irrigation investment is one of the most important activities of JCRR's agricultural development program, how to develop proper investment criteria for an efficient allocation of capital among irrigation projects was therefore selected for initial study. Since then, studies on irrigation investment have been broadened to cover economic evaluations of both large-scale and small-scale irrigation investments and private pumping of ground water, etc.

In 1961, Dr. Edward L. Rada, Associate Professor of the University of California at Los Angeles, was invited to spend a part of his time with JCRR during his stay in Taiwan from October 1961 to July 1962 as visiting professor in economics at the Soochow University in order to make an intensive study of the subject. Mr. T. H. Lee, senior economist of the Rural Economics Division, has served as his co-worker. In a period of about ten months, they devoted their entire time to the collection of statistics, data analysis, field investigation, and the drafting of a report.

As pointed out by the authors of this Report, two of our problems in Taiwan are capital shortage and its relation to agriculture. Capital shortage has to do with the sources and allocation of investment capital, while the relation of capital shortage to agriculture is a question of the capital-intensive methods employed in agriculture, principally investments in irrigation, to increase food supplies. Having discussed these two problems in the first part of their Report, they go on to explore the question of criteria in connection with irrigation investments. They approach this matter from three points of view: (1) a given project's economic feasibility, (2) the economic priority of different projects, and (3) the repayability of project costs. Finally, Dr. Rada and Mr. Lee apply the criteria thus developed to a specific irrigation investment, the Ta-Pu Reservoir Irrigation Project, which is in the nature of a case study.

This expert study represents a successful follow-up of previous JCRR's work for the intensive observation and analysis of irrigation investment problems in the context of agricultural development in Taiwan. Its authors have made several suggestions and recommendations which should prove to be valuable to the government agencies in working out economic and agricultural plans in the future. Incidentally, this Report should also be of interest to other developing areas which, like the Republic of China, are confronted with the problem of developing agricultural programs for the more effective use of scarce capital resources.

S. C. Hsieh
Secretary-General
January 1963

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ACKNOWLEDGMENTS

This study can trace its origin to the 1961 suggestion by the United Nation's International Development Association (IDA), and to its concurrence by Council for United States Aid (CUSA), that interest rated on external funds invested in Taiwan's irrigation projects be increased from 6 to 12 percent per annum. This major change in policy was adopted by American-AID authorities and necessitated a restudy of existing procedures for determining the economic feasibility of irrigation projects and of the impact higher interest rates would have on the ability of beneficiaries to repay borrowed investment funds.

The timing of the restudy was appropriate, too, in view of the world-wide concern with the economic growth of less-developed countries, and of the growing recognition that economic growth is related to choice-making among alternative capital investments.

At the suggestion of Dr. S. C. Hsieh, Secretary General of the Sino-American Joint Commission on Rural Reconstruction, the recently (1960) completed Ta-Pu Irrigation Project was selected as a case study for the economic analysis. Many hours of planning, interviewing, and tabulating were necessary in order to compile the essential farm and irrigation data analyzed and presented in this report.

This restudy would not have been possible without the wholehearted cooperation of the staffs of the Provincial Water Conservancy Bureau, the Water Resource Planning Commission of the Republic of China, the Chunan Irrigation Association, and of the Irrigation and Engineering and Rural Economics Divisions of the Sino-American Joint Commission on Rural Reconstruction. We wish to single out for special thanks from these staffs, Mr. John McCoy, Chief of the Irrigation and Engineering Division, and engineers Mr. Chin, Mr. Hu, Professor Hsu, and Mr, Y. C. Tsui, Chief of Rural Economics Division. The efforts of the economists, engineers, and statisticians would have been in vain without the cooperation of some 130 farm families in the Ta-Pu irrigation area who provided much detailed cost and benefit data.

We owe a special debt of gratitude to one colleague in the Rural Economics Division, Miss Yueh-eh Chen, Statistical Assistant, for her diligence and statistical competence.

We assume the responsibility for all errors in the data and analysis; we share the tributes with all of those who made this study and publication possible.

Edward L. Rada
T. H. Lee

Taipei, Taiwan
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IRRIGATION INVESTMENT IN TAIWAN
—An Economic Analysis of Feasibility, Priority and Repayability Criteria—

SUMMARY AND CONCLUSIONS

1. Irrigation is vital to Taiwan's intensive agricultural production. About 60 percent of all cultivated areas in 1960 was irrigated; 53 percent produced double-paddy rice. The potential paddy land is about 85 percent of total arable land. Each one percent increase in irrigated area has been associated with a 1.164 percent increase in the multiple-crop index and about a NT$ 100 million increase in the real value of agricultural production.

2. Irrigation partly accounts for the long-run decrease in the average size of farm by increasing the net value of output per hectare and thus encouraging more farming families. The average size of farm remained fairly stable, at about 2 hectares, until the 1925–40 period when the irrigated acreage was rapidly expanded. From 1940 to 1960, net irrigated acreage remained almost constant but the average size of farm continued to decrease (assisted along by commercial fertilizer) to a 1960 level of about 1.15 ha. per farm. Approximately .75 hectares of paddy land were needed in 1960 for a farm family to break-even financially; 45 percent of all farms were below this minimum level. Small farms created little or no surplus capital and they reported a high capital-output ratio. Most of their capital was tied-up in non-liquid land and buildings. To avoid more and more subsistence farming, higher surplus value crops than rice ought to be encouraged for the small acreages and/or larger-scale farming facilitated.

3. In spite of decreasing farm sizes and the resultant squeeze on the economic surplus of small farmers, farmers' savings ratios were rising—the aggregate savings from disposable income in 1960 was about 16 percent and slightly above the savings ratios in the 1930's. Rapidly rising farm prices in the late 1950's and a comparatively stable consumption level accounted for the increasing saving's ratios. Farmers were in especially good shape financially after the 40-percent rise in rice prices in

1960. Their current assets exceeded total liabilities and their only long-term debts were the final payments due for land acquired under the land-reform program. The farmers' long-term indebtedness in Irrigation Associations was only about 3 percent of their aggregate net worth of NT$ 113 billion.

4. Comparatively, Taiwan's farmers were not paying enough for irrigation water. They were paying nearly four times as much for commercial fertilizer per hectare per year as for water. The average water fee (ordinary and special) per hectare assessed (a flat rate and not related to the quantity of water used) by the 26 Irrigation Associations in 1960 was NT$ 472. Farmers buying water from private well owners in Southern Taiwan were paying as high as NT$ 6,600 per hectare in 1962 and more than NT$ 4,000 for the first crop.

5. During the 1950's, of the estimated NT$ 2 billion spent on irrigation, some NT$ 276 million were government subsidies and another NT$ 253 million were JCRR loans. Only 30 percent of the total outlay was for investment, the rest was mainly for maintenance and repair expenses, which had accumulated because of neglect in the 1930's, war damage in the 1940's, and recovery adjustments in the 1950's.

6. The water revenues collected by Irrigation Associations were distributed to three uses: operating costs, repayment of loans, and investment outlays. The ordinary fee was meant to cover all operating costs. From the evidence available, the ordinary fee assessed had not been adequate to cover the total administrative, maintenance, repair, and replacement costs. (The accounting records of Irrigation Associations for the 1950–57 period did not contain such detailed receipt-disbursement information.) The special fee was collected to repay loans. Benefited farmers were expected to repay irrigation loans in a very short time (10 to 15 years) relative to the economic life of the investment; consequently, there was much forced ex-post saving. Of the 26 associations, 17 were collecting special fees for the repayment of irrigation loans in 1960. The fees ranged from NT$ 1.69 per hectare to NT$ 250.34. No monies were collected for investment purposes until the Joint Construction Fund was started in 1959. The monies for the Fund are collected as part of the special fees. Some Associations have receipts from other sources, such as fish revenues, land rentals and sales.

7. If water were priced on the basis of full cost, the price would include the operating costs and a charge for depreciation and interest on the investment for the full economic life of the project. The price would likely be lower (but for a longer period) than the present forced-savings price charged indebted farmers but higher for those free of an irrigation-investment debt. If water were priced relative to the strength of demand (value of water to farmers) there would be a substantial rate of profit for virtually all Associations. Whether based on full cost or maximum revenue, average water prices would be substantially above existing rates and a large revolving investment fund could be accumulated from depreciation, interest charges, and profits for reinvestment in new projects.

8. Water pricing will become more complicated as more and more water is sold to non-farmers, cities and industries. In the Ta-Pu area, for example, the pulp paper companies were paying the same rate per hectare for water as were farmers. The government may need to revise its institutional and geographical organizations dealing with water. Perhaps one regional or water-basin authority would be advisable to allocate and price water among its many uses. Irrigation will remain as the major consumptive use for some time to come but more and more water projects are likely to be multi-purpose projects.

9. The irrigation projects underway and scheduled for completion in the 1960's will require an estimated NT$ 6.6 billion investment; more than all of the irrigation investments of record since 1900. The multi-purpose reservoir projects will require more than NT$ 20,000 per hectare investment while the groundwater-pumping projects can be constructed for as low as NT$ 3,000 per hectare. The major obstacle to the expansion of irrigated acreage appears to be the lack of long-term investment funds at a satisfactory interest rate.

10. As of early 1962, Taiwan had no private long-term money market. Long-term loans (over 5 years) were being made by and through government agencies. A 50-percent subsidy and 6-percent rate were traditional for irrigation investments since Japanese-occupation days; farmers came to expect such terms. However, with short-term rates at 18 percent or more per annum, and inflation at 8–10 percent each year, the continued subsidization of irrigation with foreign-aid funds was considered uneconо-

mical and inflationary. In 1960, American AID authorities stipulated 12 percent per annum and no grants for future irrigation projects. This action left irrigation development in limbo until all proposed irrigation projects could be reevaluated in terms of the new standards of economic feasibility. The recently completed Ta-Pu Irrigation Project was selected for the restudy of feasibility standards.

11. Based on agriculture's healthy balance-sheet position and the low fees paid for water, there is strong reason to believe that Irrigation Associations could generate internally much of their own irrigation investment capital. If all Taiwan's farmers belonging to Irrigation Associations paid the same water fee, varied only by the type of land farmed, the amount collected in excess of each Association's ordinary and special fees could go into a revolving investment fund. For example, a flat assessment of NT$ 1,000 per* hectare per year for irrigation water would leave an average of about NT$ 500 per year for an investment fund. This assessment would generate about NT$ 250 million annually. However, farmers contributing to the fund ought to be paid a reasonable rate of interest on their contribution. As of 1962, farmers received no interest on the money they contributed to the Joint Construction Fund; the borrowing associations paid 6 percent and the contributing associations received 5.5 percent. Eventually, all or part of these monies could be refunded to the contributors. In other words, the institutional structure required to make collections was in operation, although it needed strengthening in many ways, but the incentives for farmers' cooperation and participation were missing. Because of the large irrigation-investment needs, a system of priorities would have to be established if annual disbursements were to remain within the capacity of the revolving fund.

12. In view of the substantial rice-price tax paid by farmers before 1959, due to the price spread between the free-market farm price and the Provincial Food Bureau's official price, and the hidden tax collected from the farmers under the fertilizer-rice barter system, it would appear that

* In this connection, it should be noted that the ordinary water fee was nearly doubled to NT$ 500 per hectare per year after the August Flood of 1959. As the new assessment has already proved difficult for the Irrigation Association to collect, a flat assessment of NT$ 1,000 may be too high for the farmers to pay under the present fertilizer-rice barter system with associated hidden taxes. Consequently, our recommendation on increasing the water fee to NT$ 1,000 per hectare per year is made on the basis of suggesting that farmers contribute one half of this amount to an investment fund which could be entitled to a reasonable interest payment.

either farmers were entitled to a generous subsidy from the Food Bureau on their irrigation repayments or a generous contribution to the investment revolving fund. The latter would be more equitable to the farmers with an adequate supply of water.

13. Irrigation was but one of the many investments competing for public funds. A national system of priorities was urgently needed to ration limited funds to the numerous claimants according to their contributions to the country's economic development. Public investments ought to be categorized, for instance, by (1) national resource developments, such as water resources, flood control and forest roads; (2) national welfare, such as schools, hospitals, and so forth; and (3) the nation's infrastructure, such as roads, communications, power, and certain amounts budgeted annually for each group.

14. All public investments within categories ought to be compared by the same standards. If a 12-percent discount rate were agreed upon for the computation of present costs and benefits, it should apply as the cut-off rate for all public investments. The cut-off rate could be lowered when the long-term market rate approximated or fell below the 12 percent level. The actual selection of projects ought to be on the basis of the anticipated rate of return on each investment. On the basis of this priority schedule, the projects returning their investments the quickest would be initiated first. Cost and benefit methods, however, must be uniform among projects and the computations carefully checked.

15. The preliminary analysis of the Ta-Pu irrigation project underestimated total costs (public and private) by more than 50 percent and overestimated anticipated benefits. A careful post-project economic restudy reduced benefit-cost ratios to 1: 1.11, if only direct benefits were included, and to 1:1.35, if intangible benefits were added. A 13-percent rate of return was calculated for the total Ta-Pu irrigation investment, which would justify a 12-percent interest rate on borrowed funds. The incremental rate of return on farm capital averaged only 9.53 percent, however, in view of the large increase in farm-land values after irrigation and of most benefits planning to the many small, overcapitalized farmers. Repayment capacities, based on an average 40-percent living-allowance allotment from irrigation benefits, ranged from NT$ 1,405 per hectare, to a high of

NT$ 6,200; a median of NT$ 3,412 and an average of NT$ 3,667. The average amount required to repay total costs in 50 years at 12 percent per annum would have been NT$ 5,483 per hectare. To have repaid this amount, some farmers would have had to reduce their farm investment or consumption below their pre-irrigation levels, unless granted special repayment terms.

16. In view of the wide range in farmers' repayment capacities, their compulsory participation in the project, the unequal private benefits, and an estimated 19 percent of total benefits accruing to the public, subsidization of the Ta-Pu project was justified. Whether the subsidy as granted, a 53.5 percent grant of construction funds and the loan balance to be repaid in 12 years at 6 percent was justified, is open to question. A longer repayment period would have been in order in view of the expected 50-year economic life of the Ta-Pu project. Any lengthening of the repayment period up to 50 years would have reduced the amount of subsidy required. Many other financial alternatives and subsidy-combinations were possible.

CHAPTER I

INTRODUCTION

One of the problems common to all technologically-developing countries is the allocation of scarce resources to employments that will perpetuate rapid economic growth. Employments favoring high economic returns and internal and external (foreign exchange) savings are to be preferred.

Free China (Taiwan) is a lesser-developed country, and faces growth problems similar to other such countries. As of 1959, Taiwan ranked 30th among 95 lesser-developed nations of the world in terms of gross national income, and 50th in terms of per capita income (1). Her population growth rate and density were among the highest in the world. Comparatively speaking, Taiwan is an economically young country. Throughout most of her known history, Taiwan's status has been that of a colony first of the Dutch then the Chinese and lastly the Japanese, who controlled the Island from 1895 to 1945. After Retrocession to China in 1945, it became a Province of China and the seat of the Chinese Nationalist Government in 1949.

A young nation, economically speaking, faces many problems in getting itself into economic orbit. It is not the purpose of this paper to detail these problems. The literature abounds with discussions, analyses, and conclusions about the economic and social requirements for "take-off".

Two of Free China's problems pertaining to the capital shortage problem and its relation to agriculture are selected for special attention, however. The first concerns sources and allocation of investment capital. The second pertains to the capital-intensive methods employed in agriculture, principally investments in irrigation, to increase food supplies. The first section of this report is devoted to these two problems. The second section explores the criteria problems concerned with irrigation investments. The criteria problems may be divided into three parts: (1) a project's economic feasibility, (2) the economic priority of projects, and (3) the repayability of project costs. The third section of the report applies the criteria

developed in the second section to a specific irrigation investment: The Ta-Pu Reservoir Irrigation Project.

The objectives of this study and report are:

(1) To analyze the capital needs of agriculture, particularly the capital needs for increased food production;

(2) To evaluate the role of irrigation investments in increasing agricultural production;

(3) To utilize a case study for the purpose of demonstrating economic feasibility, priority, and repayability criteria; and,

(4) To establish performance standards that can be employed for making choices among irrigation investments and other public investments as well.

Of all of the objectives, the last is perhaps the most important.

The problem of selecting investments that yield the highest return to capital is not restricted to lesser-developed economies only. The French government attempts to allocate limited capital to its nationalized industries and to establish priorities for new projects on the basis of the highest rates of return on investment (1a). Even the United States, which the rest of the World considers a capital-surplus nation, must make investment choices and ration its investment expenditures. Added capital demands for military weapons, space exploration and foreign aid have intensified the search for reliable investment criteria applicable to all public investments. The criteria employed herein are an extension of the work of several young American economists who, since 1957, have focused their attention on the choice and allocation problems among public investments (2, 3, 4 and 5). Public irrigation investments, because of their long history, availability of records, and repayment requirements, bear the brunt of such economic inspection and analysis.

CHAPTER II

CAPITAL AND AGRICULTURE

In a young, expanding national economy such as Taiwan's, there are many obstacles to economic expansion of which the shortage of internally-generated investment capital appears to be one. The problem is particularly acute in Taiwan, a densely-populated area, because so much of her resources must be devoted to the production of the people's essential necessities of food, clothing and shelter. Agriculture, the basic economic sector, which economists consider to be the original source of industrial capital (6), has had, since Taiwan's Retrocession to China in 1945, little economic surplus left to invest elsewhere. What surplus was available economic planners considered inadequate to accelerate the economy's expansion (7). The inadequacy of capital supply from agriculture was not the only cause of Taiwan's capital shortage.

Capital Shortage

Free China's capital situation in the decade of the 1950's was one in which 52 percent of the total net investment came from external sources and the remainder, 48 percent, flowed from internal savings (8). The percentage of new investment financed from domestic savings steadily declined from 75 percent in 1951 to 35 percent in 1959, which reflected strong propensities to spend and to borrow and a weak propensity to save.

The capital shortage problem was magnified by (1) the huge post-war reconstruction needs, (2) the disorganization of the money market, and (3) the economic irrationality prevalent in the acquisition and allocation of scarce funds. Capital funds were particularly short for long-term financing.

POST-WAR RECONSTRUCTION

The uncertainties of property ownerships and values, the closure of factories, the ever-present threat of war, the shortages of goods, the influx of two million mainland-China refugees and soldiers, the reconstruction

needs of war damage, the loss of export trade, and inoperative banking and finance institutions, created such economic pressures in Taiwan in the late 1940's and early 1950's that economic order had to be restored slowly and piecemeal. Restoration capital was needed in all segments. Fortunately, agricultural production, requiring less immediate investment capital than industry and commerce, recovered quickly. An abundance of food facilitated the more orderly restoration of the other sectors of the economy.

DISORGANIZATION OF THE MONEY MARKET

Throughout this period, Free China's money market was in a chaotic condition (9). As of early 1962, it was still not functioning effectively and freely in accumulating, storing, and distributing capital funds. Inflation, as measured by a 242 percent rise in the consumer price index between 1952 and March 1962 (10), and an official devaluation of the New Taiwan dollar from NT$ 10.30 to the U. S. dollar in 1952 to NT$ 40.00 in 1960 (11) was a vexing problem. The instability of the monetary unit encouraged speculative borrowings, uneconomical investments, barter trading, and commodity hoarding. Throughout this period, rice, the Island's staple food, was a more important standard of value than money. The government bartered fertilizer, cotton goods, bicycles and power tillers to the farmers for rice (12). Taxes on rice paddy land, and payments for lands obtained under the land reform program were collected in rice, and irrigation association membership fees were computed in terms of rice equivalents (13). The government collected nearly one-third of the rice produced for (a) rationing to the armed forces and their dependents, government employees, and the poor to protect them against food price rises and thus to restrain wage increases; (b) exporting to earn foreign exchange; and (c) selling the balance on the civilian market in an effort to suppress increases in rice and other food prices.

ECONOMIC IRRATIONALITY OF THE MONEY MARKET

Interest rates of more than 20 percent per month were common in 1949–50, and a six-month's maturity was considered a long-term loan (14). As economic order was restored, interest rates gradually fell, maturities were extended, and financial institutions exerted greater influence in the money markets. Even, in 1962, however, much irrationality existed in the money-market sector controlled by financial institutions, which in Taiwan

were principally government-owned or-directed. External financial assistance, largely from the United States, contributed to the market's irrationality with loan offerings and terms that were inconsistent with respect (a) to the cost of the funds (foregone alternatives to the original tax-payers and contributors) and (b) to the returns earned by borrowers (15). Political criteria often outweighed economic criteria in the allocation of funds; if for no other reason, because economic criteria lacked formulation and precision.

The economic irrationality of the money market is further evidenced by such contrasts as the National Government paying 18 percent per annum on one-and two-year bonds while the Provincial Government was lending U. S.-aid funds for housing at 6 percent per annum for 20 years. For most of the 1950 decade, agricultural users paid 6 percent per annum for long-term investment funds, of which a half or more was given as a grant and the loan portion was to be repaid generally on an amortization basis, in 20 years or less. At the same time, farmers were borrowing short-term money from private and institutional sources at rates that ranged from 3 to 7 percent per month in 1953 to 1 to 2.9 percent per month in 1961 (16). Business firms in 1960 were paying 3.3 percent per month on secured loans on the Taipei open-market and 1.50 percent from the Bank of Taiwan, which in 1949 asked 8.4 percent (17). These were short-term loans; five-year loans were rare in 1962 and in the long-term category.

By 1962, a variety of local government and private sources had evolved to meet the needs of short-term berrowers, even though the rates seemed exorbitant by Western standards. The organized short-term market was performing the vital functions of allocating scarce funds to users able and willing to pay the high rates and attracting loanable funds away from immediate consumption. The nation's propensity to consume remained high, and government attempts to encourage investment borrowings by depressing interest rates, tended to stimulate consumption too. The money market's time-preference for funds favored investments and users that yielded high early returns, which eliminated most long-term investments from consideration. Long-term investments were being undertaken largely by the government and by government-owned business enterprises. The economic value of many such government investments was openly questioned (7).

LONG-TERM FINANCING

Long-term financing continued to be a critical problem for Free China in 1962 both from the standpoint of generating funds for such investment and of allocating such funds to their optimum uses (18).

No market-determined, long-term rate of interest prevailed in Taiwan; there was an abundance of potential borrowers but a real scarcity of long-term lenders.

The long-term loan conditions in the 1950's were in sharp contrast to the situation in the 1930's, when 50-year loans for realty purchases and irrigation were available at 6 to 7 percent per annum (19) (20). The long-term investments taking place during the 1950's were largely financed by United States' funds. From 1951 to 1961, some 55 percent of Taiwan's gross investment came directly or indirectly from external funds. Such funds flowed from AID (The Agency for International Development, formerly the International Cooperation Administration), from the Development Loan Fund (DLF), recently from the World Bank's International Development Association (IDA) and from the sale of surplus foods, provided for by U. S. Public Law 480, in the form of foreign exchange (Cooley fund), local counterpart funds, and more recently as agricultural commodities to be used for wage payments on certain public projects.

Until 1960, the standard rate of interest required on public long-term loans was 6 percent, and the demand for funds at that rate was high. Funds were allocated to projects on the basis of favorable benefit-cost ratios and the preferences of public officials. In 1961, the International Development Association suggested that interest rates charged by the Chinese Government to borrowers of IDA funds ought to be 12 percent per annum with a maximum amortization period of 40 years. The Council on United States Aid (CUSA), the liaison agency for the distribution of U. S. funds, adopted these terms for its new long-term loan policy. AID officials in Taiwan announced that commencing with fiscal year 1962, no more grants would be made except from food surpluses, and the effective interest rate on loans would be 12 percent. Moreover, loans depending on AID funds were to be approved on a project-to-project basis.

The 12 percent long-term rate remained substantially below the market rates prevailing for short-term loans. It reflected, however, the lower cost

of capital funds originating in economically more advanced countries, and the desire to encourage long-term investments yielding high returns, especially those generating high social marginal returns (21). On the other hand, the 12 percent rate was a recognition of the need for a somewhat more realistic long-term rate in view of the higher short-term rates, and for a compensatory rate against inflation. Many earlier 6-percent loans were paid off solely from commodity price increases; the windfall gains stimulated the demand for such low-cost funds and helped to inflate land values. Moreover, a 12-percent rate raised the investment-performance standard for local borrowers. Theoretically, all new long-term investments yielding marginal returns of less than 12 percent per year were automatically excluded from loan financing.

Agriculture's Capital Sufficiency

The capital sufficiency of Taiwan's agriculture is worthy of a separate and more complete study than we can attempt here; justice demands it. Statistics on this vital topic are fragmentary and measurements of capital formation are not standardized. The amount and rate of capital formation in agriculture have a bearing on agriculture's ability to finance its own capital needs and on many related public policy issues. For example, they affect agricultural tax policy, production credit policy, commodity barter policy, and a long-term loan policy for the purchase of land and cattle, the planting of orchards, the building of housing facilities, and the development of irrigation. The basic question here is: how much capital can agriculture generate for investment, especially for long-term purposes such as irrigation? First, we will examine agriculture's capital formation and then its capital needs, of which irrigation will receive special treatment.

CAPITAL FORMATION

It is estimated that at the end of 1960, the total value of assets held by Taiwan's 806,960 farm households, excluding those associated with fishery, forestry, and government farms was NT$ 121,602,966,449. (Table 1). The average size of farm was 1.15 hectares, and the average size of farm household comprised 8.8 persons*.

* These data are from a sample of 95 farm households. The average size of household is somewhat higher than that in Table 4, but the difference is attributed largely to the failure of interviewers to eliminate family members who were away in school or in the city on full-time jobs and the like. The important value data from this sample survey have been checked and rechecked against other sources and have been found quite accurate.

Table 1. Balance Sheet of Farm Households, Dec. 31, 1960[1]

(NT$)

Assets		Liabilities	
Current:	**16,513,286,971**	**Current:**	**5,536,259,675**
Cash	947,070,175	Short-term credit	3,593,006,472
Liquid	1,934,956,498	Accounts payable	1,937,239,850
Growing crop	2,820,141,765	Accrued	6,013,353
Product in storage	3,909,388,697	**Fixed:**	**2,755,975,864**
Livestock & poultry	5,427,415,456	Land payments	2,755,975,864
By-products, processing products	255,347,959	Long-term credit	—
Farm working equipment	1,218,966,421	**Total Liabilities**	**8,292,235,539**
Fixed:	**105,089,679,478**	**Net Worth:**	
Land	76,677,099,228	Capital	109,665,032,429
Building	15,338,100,082	Surplus for year:	
Furniture & household equipment	4,341,939,694	Gains	5,083,572,248
Orchards & trees	6,019,663,271	Losses	1,437,873,767
Farm machinery	2,712,877,203	**Total**	**113,310,730,910**
Total assets	**121,602,966,449**	Total liabilities & net worth	**121,602,966,449**

Footnote: [1] Based on a selected sample of 95 farm households representative of six size groups, and excludes fishery and forestry families and government-operated farms.

Current assets accounted for about 14 percent of total assets, and livestock and crops for about 50 percent of total current assets. Fixed assets represented 86 percent of total assets. Land accounted for 63 percent of total assets and 73 percent of fixed assets. Agriculture added a surplus or profit of some NT$ 3.65 billion to its total assets in 1960, which represented a net return of about 3 percent on total assets or 3.3 percent on invested capital.

Capital increases in 1960 on a per farm household basis may be studied in Table 1a. Large increases occurred in the value of building and farm machinery, farm products and in bank deposits and loans outstanding. Farmers enjoyed a healthy increase in their liquidity position.

The data need to be qualified or modified in several respects. The rice price increased nearly 40 percent in 1960, an abnormal increase that added about NT$ 3.05 billion to farmers' net incomes. Moreover, not all of the farmers' income and resultant surplus were generated from farming. About 13.5 percent of farmers' gross income in 1960 was non-farm income (22). Also, the data exclude the capital holdings of government-and

Table 1a. Net Average Increases in Capital, Per Farm Household, in 1960

	NT$	Percent
Fixed Assets		
Land	139	2.45
Building	1,408	24.80
Orchard and trees	977	17.21
Farm machinery	1,372	24.17
Working equipment	101	1.78
Sub-total	3,997	70.41
Liquid Assets		
Farm products	729	12.84
Livestock and poultry	— 255	— 4.49
Others	— 60	— 1.06
Sub-total	414	7.29
Financial:		
Cash	309	5.44
Bank deposits and lending	982	17.30
Loan payments	— 25	— 0.44
Sub-total	1,266	22.30
Total	5,677	100

Source: Preliminary Report on the Farm Account in Taiwan, 1960, Provincial Department of Agriculture and Forestry, December 1961.

non-profit institutions engaged in agriculture and the vast fixed-asset holdings of farmer-owned irrigation-and farmers' associations.

Agriculture's overall financial position was extremely strong in 1960; its liabilities were negligible relative to assets. Current assets were twice as large as total liabilities.

Rate of Saving in Agriculture—The total assets represent an accumulation of more than 300 years of agricultural development in Taiwan, and a long-run rising price level. The real rate of capital growth, of course, was not constant. Lacking both adequate historical statistics and a proper value-deflating index, no satisfactory time-period comparisons are hazarded. There is reason to believe, however, that the capital accumulation rate in agriculture was more rapid from 1900 to 1930 than from 1930 to 1960*.

* Taiwan's agriculture experienced a boom in the 1920's. The agricultural production index (1935-37=100) increased from about 49 in 1920 to about 93 in 1932. Although the rate of production increase was greater after World War II—rising from about 48 in 1945 to 155 in 1960, there is reason to believe that much of this gain can be attributed to the greater use of existing production facilities and the flood of capital from outside agriculture into agriculture, than to the high rate of capital accumulation within agriculture. Also, the farmers' first concern after the war was to restore their pre-war levels of living, especially in food consumption.

In the 1900–1930 period, the Japanese purposely developed Taiwan as an important source of foodstuffs for Japan proper. A variety of inducements were employed to stimulate agricultural production and capital investment. By the 1930's, agriculture was supplying capital for Taiwan's industrialization (23). This could only take place if agriculture were accumulating a surplus and a surplus that earned farmers more if invested elsewhere than in their farms.

Estimated farm-savings ratios for 1932 and since the 1950's are presented in Table 2. The savings rate in 1932 which ended a ten-year period of rapid growth, amounted to 12.4 percent of disposable farm income. During the early 1950's agriculture was still suffering from its wartime setbacks, price controls were prevalent and levels of living were low. The savings ratio was low, too, as reflected by the 7.5 percent savings rate in 1950. Beginning with 1959, the annual saving ratio exceeded the 1932 level, and attained a rate of 16 percent in 1960. This favorable savings response can be attributed to: (1) rising incomes due to a combination of rising prices, particularly for rice, and increased outputs and (2) a stabilized consumption level. If agriculture, especially rice farmers, had been given the full benefit of the market price for rice, as indicated in Table 10 and to be discussed more fully shortly, agricultural recovery would have been more rapid and the savings ratios substantially greater.

Table 2. Comparative Saving Ratio in Agriculture for Selected Periods from 1932 to 1961 (in 1952 prices)

Year	Disposable farm family income per farm household (1) (NT$)	Consumption per farm household (2) (NT$)	Savings per farm household (3) (NT$)	Saving ratio $(4)=\frac{(3)}{(1)}$ (percent)
1932	10,463	9,163	1,300	12.42
1950	8,581	7,937	644	7.51
1954	9,479	8,970	509	5.37
1957	8,791	8,108	683	7.77
1958	10,403	9,404	999	9.60
1959	10,005	8,574	1,431	14.30
1960	10,798	9,072	1,726	15.98
1961	11,489	9,853	1,636	14.24

Source: Rural Economics Division, JCRR

An increasing saving rate could lead to some important consequences for agriculture and the economy. The added savings might be (a) used

for increased investment in agriculture, (b) invested outside agriculture, or (c) foregone for more consumption. The relative rates of return from the investment alternatives will determine in which direction the savings will flow. From all indications, farmers were reinvesting in agriculture (Table 3), but not as rapidly as their increase in savings. There is reason to believe, too, that they were lending more outside of agriculture, too (see Table la and 9). Returns from both internal and external investment alternatives were still high enough to discourage greater present consumption. As interest rates fall, which can be anticipated with increased capital accumulation, farmers' consumption and living levels are likely to rise.

Capital-output Ratio in Agriculture.—As might be safely predicted from the higher rates of savings, internal investments on farms were increasing, too. Internal investments were increasing more rapidly than the value of output, as is indicated by the rising capital-output ratios in Table 3. However, they were not increasing as rapidly as the rate of savings, which suggests a diminishing rate of return from internal investments. There are many reasons for the lack of more profitable reinvestment opportunities in individual farms but one of the major ones is the decrease in the average size of farm.

Table 3. Estimated Capital-Output Ratios in Agriculture, for Selected Periods from 1931-32 to 1960

Period	Capital in use[1] (NT$ Million)	Output (NT$ Million)	Capital-Output ratio
1931-32	1,703	1,020	1.67
1950	12,912	10,769	1.20
1958	26,139	20,006	1.30
1959	30,880	21,115	1.46
1960	59,324	34,681	1.71

[1] Excluding land value.
Source: Compiled from farm surveys by the Rural Economics Division, JCRR.

What accounts for the decreasing farm size, and what effect does it have on capital formation?

Decreasing Farm Size.—The two determinants of farm size are: number of farmed acres and number of farm households (Table 4). For the 1900–60 period, the net gain in arable land used by agriculture was

320,000 hectares, a 60 percent gain. (The gross increase was larger, but much arable land was lost yearly to non-agricultural uses.) The more than 100 percent increase in farm households from 1900 to 1960 is attributable to many factors. The increase in population is one but singularly not the most important. The relative superiority, and security, of agricultural incomes is perhaps the most important single factor. The comparative income advantage in agriculture, in spite of smaller farms, was due largely to increased outputs that can be traced to biological and technological improvements, among which irrigation is extremely important.

Table 4. Farm Size Characteristics, by Decades, 1900 to 1960

Period	Farm household (no.)	Area (ha.)	Ave. size of farm (ha.)	Ave. size of farm household (persons)
1900-09[1]	368,787	554,481	1.50	5.32
1910-19[1]	373,164	704,248	1.89	5.95
1920-29[2]	395,715	774,110	1.96	5.40
1930-39	417,685	833,369	2.00	6.56
1940-49	507,472	843,944	1.66	6.69
1950-59	718,628	875,070	1.22	6.29
1960	785,592	869,223	1.11	6.84

[1] Estimated. [2] 1922-29 average.

Source: Annual issues of *Taiwan Agricultural Yearbook*, Provincial Department of Agriculture and Forestry, Taipei, Taiwan.

Irrigation, in other words, helps induce small-size family farms. The irrigated double cropping paddy-land plots are significantly smaller than the single-cropping paddy land or upland plots (Table 4a).

Table 4a. Percentage of Cultivated Land, by Type of Land Use and Size of Plot

Size of plot (Chia)[1]	Total (percent)	Double-cropping paddy land (percent)	Single-cropping paddy land (percent)	Upland (percent)	Tea & orchard planting (percent)
Under .5	100	40.32	18.40	36.72	4.56
.5 to 1.0	100	46.81	19.87	28.50	4.82
1.0 to 1.5	100	43.50	21.60	29.09	5.81
1.5 to 2.0	100	39.93	23.11	30.16	6.80
Over 2.0	100	29.40	24.15	34.30	12.15
All	100	38.31	22.11	31.66	7.92

[1] One chia is the equivalent of 0.96992 hectares or 2.3968 acres.

Source: Committee of Sample Census of Agriculture, Taiwan, China, *Report on the 1956 Sample Census of Agriculture*, Aug. 1959, pp. 64-65.

Until about 1940, farm sizes were increasing; the amount of land farmed increased much more rapidly than did the number of farm households. Since 1940, the reverse has been the case. The big increase in the irrigated acreages in the 1920's (Table 11) and the greater use of commercial fertilizers in the 1930's (Chart 2) led to increased net farm incomes, which in turn attracted people into farming. The attraction increased especially after the large increase in population following Retrocession. The impact of the declining farm size on agriculture's capital formation and needs is revealed in recent farm economic studies.

Impact of Farm Size on Capital Formation.—Tsui, for example, reported that, in 1957, farms of less than 0.5 hectares, which accounted for 34 percent of all farms, experienced an operating loss of more than NT$ 600 per year (24). On the other hand, farms of two hectares or more in size, which accounted for only 11.5 percent of all farms, reported an average surplus exceeding NT$ 5,000 per household. These findings were supported by the 1960 agricultural census which indicated that on the basis of 1959 output and prices, a farmer needed 0.75 hectares to break-even financially. About 45 percent of all farms were below this size.

On the other hand, the capital-output ratio by size of farm (Table 5) reveals a large investment in small farms (largely in fixed assets) relative to income. Agriculture in Taiwan has not yet reached the turning point at which average farm size begins to increase, as it has in Japan (25).

In spite of government attempts to stem the decline in farm size, principally through the land consolidation program, many factors—irrigation, fertilizer, credit, population growth, low industrial wages, inflation—favor a continued decrease in the average farm size, and an internal over-capitalization in agriculture.

Prior to Retrocession and the land reform that followed, much of the farm land was owned by large landlords many of whom were non-farmers. Land reform, accomplished in several stages from 1949–1954, transferred tenanted lands to the cultivators which increased the number of owner-cultivators from 61.4 percent before to 84.8 percent after reform. Rents on lands remaining in tenancy were reduced from 50 percent or more of the principal crop to a maximum of 37.5 percent. Rents formerly paid to landlords were retained by the new owner-occupants or used to acquire

Table 5. Average Capital-Output Ratios per Farm, by Farm Size, 1960

Unit: NT$

Farm size (ha.)	Gross farm income	Intermediate cost[1]	Net farm income (1)	Total assets (2)	Fixed assets (3)	Liquid assets (4)	Capital-output ratio (2)/(1)	Fixed capital-output ratio (3)/(1)	Liquid capital-output ratio (4)/(1)
Less than 0.5	23,798	14,651	9,147	63,422	55,373	8,049	6.93	6.05	0.88
0.5-1.0	37,522	14,612	22,910	103,563	88,122	15,441	4.52	3.85	0.67
1.0-1.5	47,932	16,720	31,212	211,659	187,178	24,481	6.78	6.00	0.78
1.5-2.0	58,294	20,369	37,925	189,248	163,191	26,057	4.99	4.30	0.69
More than 2.0	81,835	23,144	58,691	274,421	241,700	32,721	4.68	4.12	0.56
Average	52,372	17,691	34,681	179,588	156,707	22,881	5.18	4.52	0.66

[1] Value of goods used in production.

Source: Estimated from ***Farm Economy Survey of Farm Records,*** Provincial Department of Agriculture and Forestry, 1960.

Table 6. Capital Inputs of Selected Crops, and Hogs, per Hectare or Head, Expressed as Percentages, 1959.[1]

	Self-supplied %	Cash %	Fixed Capital %	Total %	Hectares planted in Taiwan ha.
Sweet potatoes	57.10	28.31	14.59	100.00	226,486
Peanut	60.24	23.93	15.83	100.00	99,135
Pineapple	31.06	55.78	13.16	100.00	8,884
Wheat	37.10	41.28	21.62	100.00	22,841
Chinese cabbage[2]	60.40	28.28	11.32	100.00	7,205
Tea leaf	36.39	37.69	25.92	100.00	48,442
Soybean	43.27	37.16	19.57	100.00	53,785
Banana	44.16	49.00	6.84	100.00	12,962
Rice	35.85	31.73	32.42	100.00	776,050
Hogs	59.96	36.78	3.26	100.00	3,263,633[3]

[1] Per year for pineapple and tea, per crop (about three months) for other crops, per head (about 9 months) for hogs.
[2] Data are for 1958.
[3] Numbers stocked in Taiwan.
Source: Appendix A, Table A-1.

requisitioned land from the government (see Table 1 for the amount remaining to be paid as of 1960), which had purchased the land from landlords with rice-and sweet-potato bonds and public-enterprise stocks.

According to Tang and Hsieh (26), the savings ratio in agriculture dropped after land reform from 14.2 percent of total farm income in 1950 to 10.2 percent in 1955*. How much of this decline can be attributed to the effects of land reform and how much to the continuing decrease in farm size is unascertainable. Land reform had two important impacts on capital formation. First, it resulted in a redistribution of capital-asset ownerships and the large landlords, who were important savers and investors in agricultural and industrial development in earlier years, were eliminated from this role. Second, it discouraged the purchase and holding of land by non-farmers as an income-earning investment.

After 20-years of war and post-war readjustments, the internal rate of capital formation in agriculture is increasing again and total unencumbered capital holdings are large. On the other hand, it appears that the growing

*Savings ratios of agriculture shown in this paragraph are slightly higher than those shown in the preceding Table 2. The reasons for this difference are: (1) a different approach is used; social accounting for these data and individual farm records for the former; (2) the scope of the latter includes both private farms and large corporate farms, but the former includes only the private farms.

number of small farmers are finding it more difficult to supply their own capital needs, especially for intermediate—and long-term investments.

CAPITAL NEEDS

Agriculture in Taiwan, as elsewhere, required three types of capital: the recurring short-term production capital for seeds, fertilizers, pesticides, and hired labor; intermediate-term capital for investments in power equipment, draft animals, farming tools, plant propagating material, food and feed inventories; and, long-term capital for irrigation facilities, orchard plantings, housing for people, animals, equipment, and land. These items, differing in degree of magnitude and economic life, constitute the bulk of a farmer's operating capital requirements.

Estimated annual capital needs of Taiwan farmers, producing a selected group of important crops and hogs, are shown in Appendix A, Table A–1. As indicated, each crop or enterprise requires a different quantity and type of capital. These 1959 statistics are regrouped in Table 6 to show what percentage of the capital is required as cash (the short-term production credit), as long-term, fixed-capital credit, and is self-supplied. Total capital needs in 1959 can be estimated by multiplying the per hectare requirements by the number of hectares planted to each crop, and the per hog requirements by the number of hogs stocked.

The statistics are less than adequate in several respects. They do not represent an average or optimum-size of farming unit. Moreover, they assume a static situation, no allowance is made for added capital investments, growth in capital needs, or in capital accumulation. Common overhead costs are likely to be understated and misallocated particularly since most crops are produced jointly or in rotation with other crops. Also, the fixed-capital flows do not include the costs of fixed-capital collectively owned by farmers in irrigation and marketing facilities and which account for external economics and higher farm incomes.

The capital statistics in Appendix A, Table A–1, tend to conceal the real intensity of capital needs or use in Taiwan. On a per hectare basis, we can observe that of the crops represented, pineapple requires the most capital followed by Chinese cabbage, banana, rice and wheat. Peanut and sweet potato production require the least. Weighted by number of hectares planted, it is apparent that any expansion of rice, banana and vegetable

plantings will require increased amounts of capital, largely for irrigation which is included in the category of "taxes and others" (27). However, recent studies of dairy farming in Taiwan show that a combination dairy-rice farm requires 65 percent more capital than does a rice farm alone (28). The expansion of animal agriculture will call for more production and investment capital than required for crop production alone.

On an annual basis, capital needs are determined by the length of the production cycle. Some crops, such as rice, peanuts, vegetables have a production cycle of about three months and in some localities four crops a year are produced on the same hectare of land. This is rare, but possible. Where possible, the common practice is to plant other crops such as sweet potatoes, peanuts, wheat, soybean or vegetables, between the first and second crops of rice Other crops, such as pineapple and sugar, produce harvests every 12 to 18 months. The multiple-crop index in Taiwan has increased steadily from 111 in 1945 to 184 in 1960, with the total farmland area in each year as the base of 100* The intensity of land use in 1960 is indicated in Table 7. Obviously, the total amount of yearly production capital required on multiple-crop farms per hectare will be a multiple of the crops produced. Capital turnover, depending on the amount of fixed-capital invested, also will be greater, and the capital-output ratio smaller. Intensive cropping, then, tends to offset somewhat the adverse capital-output effects of small-

*The statistics in Table 7 indicate a positive correlation between the percent of cultivated land irrigated and the multiple-cropping index. A statistical correlation for these data, exclusive of the data for Yilan prefecture because of its wide deviation from the normal pattern due to poor weather conditions in the winter months yielded a regression coefficient of 0.8379. The linear regression line ($Y=a+bx$) produced values of $Y=129.71+1.164x$ which indicates that the multiple-crop index without irrigation would be roughly 130 (as substantiated by the experience in the non-irrigated Penghu prefecture). With every 1 percent increase in irrigated land, the multiple-crop index has increased by 1.164 percent. If all cultivated land were irrigated, this formula would produce a multiple-cropping index of 246 or 34 percent more than the 1960 average of 184. It is estimated that the maximum potential multiple-cropping index is 300. These data indicate that even if all cultivated land were irrigated, the multiple-cropping index would fall short of the potential. In other words, other factors than irrigation have a bearing on the multiple-cropping index.

Pursuing the significance of the multiple-cropping index a bit further, we find that for the periods of 1900–1939 and 1950–1960, the relationship between the multiple-crop index and the real value of crop production (gross value deflated by the general price index, 1950–52=100) averaged about NT$100 million increase in crop value for each 1 point increase in the multiple-crop index. (The regression coefficients were about 0.95 for both periods). Tracing this cause and effect relationship back to irrigation, we might conclude that a one percent increase in irrigated acreage would result in an increase of NT$116 million in the real value of crop production. If all remaining unirrigated cultivated land were to be irrigated, the increase in the total value of crop production, disregarding future changes in cropping patterns and crop prices, would result in an increase of crop values of roughly NT$7.0 billion annually.

size farms.

For a variety of reasons, but chiefly because of the favorable net returns attributable to irrigation and fertilizers, crop patterns have continued to move toward the labor—and working-capital intensive crops and away from fixed-capital-intensive land uses. Hsieh and Lee report, for example, that the working-capital index rose from 100 in 1950 to 195 in 1960. Not so for the fixed-capital index. It reached only 113 in 1960 compared to 100 in 1950 (29). Agricultural investment in fixed capital, notably machines, land improvement, and irrigation, has lagged since Retrocession.

At this point, it is interesting to note Appendix A, Table A-1, the significant difference in the relative amounts spent by farmers for fertilizers

Table 7. Intensity of Land Use, by Prefectures, in 1960

Prefecture	(1) Cultivated land area (Ha.)	(2) Irrigated land area (Ha.)[2]	Cultivated land irrigated (2)/(1) (%)	Multiple cropping index (%)
Taipei	50,950	21,497	42.19	165
Yilan	27,949	23,122	82.73	190
Taoyuan	54,842	32,998	60.17	193
Hsinchu	42,440	10,616	25.01	164
Miaoli	41,415	16,076	38.82	187
Taichung	46,331	38,781	83.70	232
Changhwa	76,070	59,908	78.75	233
Nantou	46,228	19,190	41.51	143
Yunlin	86,441	20,730	23.98	195
Chiayi[1]	71,685	149,333	34.31	159
Tainan[1]	96,945			
Kaohsiung	53,803	24,001	44.61	187
Pingtung	77,820	41,154	52.88	196
Taitung	30,612	8,572	28.00	147
Hwalien	31,818	10,673	33.54	167
Penghu	7,283	—	—	132
Average			41.96	184

(1) An estimated 137,216 hectares in Chiayi and Tainan perfectures were irrigated on a three-year rotation; farmers could obtain water for only one crop every third year. Most of the irrigated area was in the Chianan Irrigation Association. The data for the two perfectures are combined for computing averages and percentages.

(2) Irrigated land area was the 1959 figure quoted from the 1960 agricultural yearbook. Because figure of irrigated land area in the 1961 agricultural yearbook seemed too high to believable compared with 1959, 1961 and 1962 figures.

Source: Provincial Department of Agriculture and Forestry, *Taiwan Agricultural Yearbook*, 1960 and 1961 editions.

and for irrigation. Fertilizer purchases ranged from slightly more than 6 percent to nearly 30 percent of total production expenses. On a per hectare basis, farmers applied NT$ 768 worth of fertilizer per rice crop in 1959.

For two crops of rice per year farmers expended about NT$ 1,500 for commercial fertilizer. On the other hand, irrigation, which is fundamentally more important to farmers* than fertilizer, accounted for 3.88 percent of all production expenses in 1959–1960. On a per (irrigated) hectare basis, water costs in 1959–60 (ordinary and special fees of all irrigation associations) amounted to only NT$ 482 per year. (See Table 23 for a record of 1960 water fee assessments and collections by irrigation associations). These statistics suggest that either fertilizer was overpriced relative to irrigation or that irrigation associations underpriced irrigation water. Irrigation water, a product of a collective, fixed, long-term investment is easily underpriced. If both were appropriately priced, the exchange ratios might favor fertilizer but not by the 1959 ratio of 3.5:1.

Long-term capital needs for agriculture, including irrigation, have been projected by government planners for each of Three Four-Year Plans; the last covers the 1961–64 period (see Appendix A, TableA–2). The amount of total capital needs allocated for fixed-capital long-term agricultural investment are scheduled to increase from NT$ 1.5 billion in 1961 to NT$ 2.6 billion in 1964. The amount allocated for water resource development is to increase from 24 percent of the total in 1961 to 44 percent in 1964 (Table 8). Irrigation development projects are to receive 15 percent of all agricultural capital investments in 1961 and 35 percent in 1964. By 1964, about 80 percent of all water-resource-investment spending is to be for irrigation development. The statistics in Appendix A, Table A–2 show that more than half of the investment funds are to come from government, of which more than 60 percent are from U. S.-aid sources. The private share of all agricultural capital investment is scheduled to increase but slightly from 43 percent in 1961 to 46 percent in 1964.

FINANCING AGRICULTURE'S CAPITAL NEEDS

The investment capital required by farmers comes from two basic

* The comparative productivity of water and fertilizer is not easily measured. In real life, they are complementary but on the margin they may be substitutes. If a farmer had a limited fund to invest and was faced with an either or choice, irrigation water would more than likely be his best buy. The relative importance of each separately and in combination could be tested empirically in field trials. A theoretical model could then be constructed from estimated irrigation- and fertilizer-production functions.

sources: internal and external. Internally, farmers may create capital by using their own labor with tools or they may obtain working capital from current or saved income (including the sale of fixed assets). External funds may take the form of gifts, loans, periodic grants or continuing subsidies. The external funds may come from individuals, farmers' associations, cooperatives within agriculture, or from governments and lending institutions not directly related to agriculture. The flow of funds is more likely to be larger out of agriculture to other investments offering higher rates of return than into agriculture from outside sources.

Table 8. Capital Investments in Agriculture and Irrigation in Taiwan's Third Four-Year Plan, 1961 to 1964

Unit: NT$ Million

Type of investment	1961	1962	1963	1964	Total
Total agricultural investments	1,470	1,810	2,171	2,575	8,026
Total investment in water-resource development	347	597	858	1,141	2,943
New irrigation development(1)	68	155	285	549	1,057
Irrigation improvement projects(2)	158	274	332	344	1,108

(1) Gravity irrigation, diversions and reservoirs, and pumping irrigation.

(2) Ground water development, rotational irrigation, canal lining, irrigation canal extensions.

Source: *The Agricultural Program under Taiwan's Third Four-Year Plan* Agricultural Planning and Coordination Committee, Ministry of Economic Affairs, Republic of China, December 1961, pp. 27-28.

The sources of farm investment funds have changed in character and significance since 1894, the beginning of the Japanese-occupation period.

Before Retrocession.—According to data compiled for the Japanese-occupation period, Taiwan's farmers supplied most of their own production credit needs, and in later years helped finance the Island's industrialization (23). The rural credit cooperatives, for example, had deposits of OT$ 130,459,159 in 1939 and some OT$ 116,082,915 loans outstanding. Converted to 1961 amounts of NT$, with the aid of a continuous price index, the figures would be the equivalent of NT$ 3,669,816,413 and NT$ 3,265,412,399, respectively (30). Business firms were large borrowers from the rural cooperatives.

The Japanese government provided considerable long-term credit assistance. New large-scale irrigation investments were subsidized with outright grants. Until 1922, and after 1940, the amount contributed by

government exceeded the investments made by irrigation associations. Farmers' irrigation associations were organized to operate, maintain, and replace the irrigation facilities from funds collected from the water users. (See Appendix B, Table B-1 for a historical account of such financing from 1901 to 1945.) In addition, Japanese-controlled banks extended long-term loans, up to 50 years, at interest rates below 10 percent. Japan's outlay for Taiwan's long-term loans, subsidies, and government expenditures was more than repaid from handsome profits earned from Taiwan's sugar, rice, and bananas exported to the homeland (31).

From 1939 to 1945, Taiwan's agricultural production fell from an index of 107 to 48 and capital deficits were more common than surpluses. All of the credit institutions serving agriculture became inoperative or ineffective during the war-and-transition period. Those institutions that survived were transferred to Chinese operation and control. The Bank of Taiwan organized in 1899, continued performing central bank and commercial bank functions as well. The newly-named Lank Bank, was formerly a branch of the Hypothec Bank of Japan that specialized in supplying long-term credit (32). The Cooperative Bank of Taiwan, originally the Central Bank for rural credit cooperatives and established in 1944, was reoriented to serve the short-term credit needs of a variety of cooperatives including farmers' associations whose 305 credit departments assumed the functions of the disbanded rural credit cooperatives. Some 84 credit cooperatives in large townships and cities, formerly a part of the rural cooperative system, acquired stock memberships in the new Cooperative Bank. Their funds, largely from agriculture, serve the credit needs of urban dwellers and businessmen.

After Retrocession.—Shortage of agricultural capital in the early 1950's prompted the Chinese-American Joint Commission on Rural Reconstruction to make money grants to beleaguered farmers' associations for production credit and to irrigation associations for repair of war-neglected-and-damaged irrigation facilities. These grants totalled NT$ 468,396,000 from 1950 to 1955. In 1955, JCRR initiated a self-help program of granting loan funds to farmers' associations on a matching basis. With JCRR aid, the FAs' agricultural production loans increased from NT$ 3 million in April 1955 to NT$ 106 million in September 1961 (33).

In 1960, farmers obtained 24 percent of their cash loans from FA's compared to 18 percent in 1952 (33a). Private sources provided 43 percent of the farmers' credit needs in 1960 compared to 64 percent in 1952. The balance came from other sources such as the Land Bank, the Taiwan Provincial Food Bureau and the Taiwan Sugar Corporation, all government-owned enterprises. In both 1952 and 1960, large farmers obtained substantially more credit from private sources, slightly more from FA's, and much less from other sources than did small farmers.

The amount of production loans obtained from other than private sources, from 1951 to 1960, is estimated in Table 9. Production credit extended from government and cooperative sources increased much more rapidly than did agricultural production. By 1960, nearly 20 percent of the annual production value (assuming an annual capital-turnover ratio of 1) was furnished by these sources. The credit from government sources since 1955 increased by about 10 times while that from cooperative sources increased by less than four. Production, on the other hand, increased by only twice its 1955 value.

These credit trends raise some interesting question. First, are they not contradictory to the Third Four-Year Plan which calls for a diminishing role for government credit and an increasing role for private credit, Appendix A, Table A–2. Second, are government lending terms more favorable to farmers than those from private sources, or is the supply of private funds for lending to farmers diminishing?

The volume of private lending increased about four times from 1952 to 1960 (footnote, Table 9). Larger farmers, as we have noted above, continued to prefer private credit which suggests that they have been able to borrow at better terms than those offered by government. Smaller farmers, then, were the chief beneficiaries of government-supplied credit. Third, does an expanding use of external credit, offered at lower interest rates, indicate a real need for or a substitution of less expensive public capital for a farmer's own capital that can earn more elsewhere? No doubt, there is an element of both. An expanding volume of credit is not *per se* an evidence of need, and high rates not a proof of usury or exorbitant profits. Fourth, has the increased use of credit resulted in greater agricultural production and productivity? Without question, credit increased the produc-

tivity and production on some farms, especially on those altering land-use patterns, adapting to new market opportunities, or changing cultivation methods or techniques. In the aggregate, however, production had not increased as rapidly as the volume of borrowing. Fifth, was there not another way of providing farmers with investable funds rather than through subsidized credit? For example, if the official rice-price controls had not been in effect, rice farmers could have increased their annual earnings by nearly the total amount of loans supplied by government (33a).

Table 9. Production Credit from Government and Cooperative Sources,[1] 1951 to 1960

Period	Loans from			Total production loans (NT$ 000)	Gross value of agric. production (NT$ 000)[5]	Loan-to-value ratio (percent)
	Government[2] (NT$ 000)	JCRR[3] (NT$ 000)	Cooperative sources[4] (outstanding at the end of year) (NT$ 000)			
(1)	(2)	(3)	(4)	(5)	(6)	(5)/(6)
1951	92,662	9,699	70,499	172,860	3,812,441	4.5
1952	155,462	16,737	184,156	356,355	5,837,552	6.1
1953	152,686	19,694	269,533	441,913	8,681,412	5.1
1954	110,876	21,459	353,453	485,788	7,430,644	6.5
1955	159,973	44,625	572,824	777,422	9,494,860	8.2
1956	180,110	46,447	729,897	956,454	10,574,045	9.0
1957	125,879	60,563	833,503	1,019,945	12,390,940	8.2
1958	1,150,074	54,571	1,329,104	2,533,749	13,709,273	18.5
1959	1,135,508	97,065	1,785,522	3,018,095	15,611,830	19.3
1960	1,490,272	151,999	1,980,984	3,623,255	20,659,550	17.5

[1] Does not include credit from private sources. In 1952, private credit was estimated to supply 64 percent of all credit which if added to that shown in this table would make the total external production credit exceed 1 billion. In 1960, private credit was down to 43 percent which suggests that the total production credit used by farmers exceeded more than NT$ 6 billion. The adjusted loan-to-value ratio for the two years would be roughly 17 and 30 percent, respectively. Credit from private sources increased in amount from about NT$ 600 million in 1952 to NT$ 2.5 billion in 1960.

[2] Mostly the loans of the Provincial Food Bureau, Taiwan Sugar Corporation and the Taiwan Tobacco and Wine Monopoly Bureau to farmers.

[3] Amounts released through FA's by JCRR. In addition, JCRR has made more than NT$ 800 million in grants-in-aid, of which more than NT$ 300 million went into irrigation.

[4] Mainly credit cooperatives, cooperative banks and farmers' associations. The statistics exclude JCRR assistance. The data represent balances outstanding at the end of the year. Most loans are for a year or less although since 1958 loans with maturities of more than one year have increased substantially.

[5] Includes the value of agricultural production on government-operated farms, which was estimated to be about 2 percent of all production in 1960.

Sources: Credit data estimated by Rural Credit Division, JCRR; value of agricultural production from annual editions of *Taiwan Agricultural Yearbook*, Provincial Department of Agriculture and Forestry.

Rice farmers, accounting for more than 80 percent of all Taiwan farmers, had been denied the full market price for about 30 percent of their rice production collected by the government since Retrocession. The price spread for ponlai rice between government purchase and free market amounted to NT$ 2,087 and NT$ 1,724 per m/t in 1960 and 1961. With the quantity of 599,778 m/t and 738,325 m/t collected by government in 1960 and 1961, the total difference of farmers' return amounted to more than NT$ 1.2 billion each year (Table 10). If received by farmers, all of this money, less added consumption expenditures and taxes, would have been made available for reinvestment in agriculture or in local industries, whichever offered better returns.

Table 10. The Preempted Value to Farmers of Rice Collected[1] and Compulsorily Purchased by Government 1951-1961

	Price spread[2] NT$/m/t.	Rice collected from farmers m/t.	Total value NT$
1951	224	404,227	90,546,848
1952	679	425,467	288,892,093
1953	1,224	423,308	518,128,992
1954	565	525,938	297,154,970
1955	639	496,354	317,170,206
1956	813	515,664	419,234,832
1957	935	535,347	500,549,445
1958	898	650,641	584,275,618
1959	933	606,301	565,678,833
1960	2,087	599,778	1,251,736,686
1961	1,724	738,325	1,272,872,300

(1) Ponlai rice, brown-rice equivalents.
(2) Amount official-rice price below free market-farm-rice price.
Source: Computed from Taiwan Provincial Food Bureau's, *Financial Operating Statements.*

The rice-money profits collected by the Provincial Food Bureau were used to subsidize the food consumption of special groups, notably the military and government personnel, and an infant fertilizer industry, whose production costs in 1962 were still above world market prices.* The net contribution, i. e., benefits minus costs, of this complex subsidy system to the nation's welfare is questionable, particularly if measured against net benefits from alternative uses of the funds.

* It is estimated that the Provincial Food Bureau earned a net profit of more than NT$ 423 million in 1962 from the sale of imported and locally-produced fertilizer to Taiwan farmers. About 90 percent of the profit came from imported fertilizer (33b).

Part of these rice profits to the government could be attributed to increased rice production due to irrigation. These direct tangible public benefits might justify public subsidies for irrigation investments.

Financing Long-term Agricultural Projects.—Except for farm housing, most long-term investment financing in agriculture, since the Retrocession, has come from government sources. For example, some 267,595 tenants, with the aid of government, purchased NT$ 3.5 billion of lands (1952 prices) under the land reform program.*

The average loan was NT$ 13,235 per farmer and amortization payments represented about 3 percent of his annual income. Nearly all loans were to be paid off by 1962–63. Government officials are anxious that after land-payments are completed equivalent amounts be saved for reinvestment in agriculture or industry (34).

The long-term amounts invested in irrigation before and after Retrocession are treated in detail in the next section.

Summary

We have presented numerous exhibits pertaining to capital formation and accumulation in agriculture all of which suggest that Taiwan's agriculture, in general, has a considerable ability to generate investment capital and considerable capacity to absorb credit. Its financial position is fairly strong. In recent years, farmers' propensities to save has been increasing relative to their propensities to consume. Farmers will soon pay off most of their individual long-term debts which were incurred for the acquisition of land under the land reform program.

* Taiwan's land reform program included the purchase of private and public land. Land price was calculated to be paid in kind with paddy rice and sweet potato. The total value of the land price, as estimated in 1952 prices, was as follows:

Ownership of land purchased	Land area purchased		Land price	
	Paddy (chia)	Dry (chia)	Paddy (rice) (m/t)	Dry (Sweet potato) (m/t)
Private land	121,535	22,033	1,525,211	519,358
Public land	29,078	30,539	231,473	535,497
Total	150,613	52,572	1,756,684	1,054,855

Prices of paddy rice and sweet potato used for estimation were NT$ 1,868 and NT$ 246.60 per m/t respectively in 1952. The total land price payments amounted to NT$ 3,541,612,955 on the basis of the above prices.

On the other hand, it appears that agriculture has not been investing enough in irrigation either in absolute or relative terms. It has come to depend on government for much of its irrigation investment needs and is becoming more and more dependent on government for its production credit needs. It has become accustomed to generous government subsidies and low-interest loans, and objects to the post-war readjustment terms asked by other lenders.

One of the greatest needs is to create the necessary institutional arrangements and conditions conducive to the collection of more investment funds from within agriculture for its own needs.* Steps already have been taken through farmers' associations to harness more of agriculture's internal funds for its own production credit needs. There is reason to believe, however, that until farmers' savings in such organization are insured and guaranteed against confiscation, farmers will not wholeheartedly support such institutions. They may invest a token of their savings in such credit organizations but their greatest security, as in the past, will lie in the diversification of their investments with the emphasis on land.

The accumulation of funds for longer-term investments such as irrigation poses a different set of problems. The organizations for administering irrigation facilities and collecting monies to cover costs are already in existence in the form of irrigation associations. An Island-wide association of Irrigation Associations known as the Joint Council of Irrigation Associations is in existence, too.

It seems appropriate at this point to examine the nature and magnitude of irrigation investments, past, present and future, and then to examine the methods employed for the financing of irrigation investments.

* The problem here resembles that reported by Hirschman based on his experience in Latin America. He states, in part, "In underdeveloped countries...we may perhaps say that a readiness to save and invest exists, but is being frustrated..." (34a).

CHAPTER III

IRRIGATION INVESTMENTS

Inasmuch as the central topic of this study is irrigation investment, it is deserving of special treatment. Our concern in this section is with three aspects of irrigation investments: (1) past and projected irrigation investments, their magnitude, frequency, and sources of funds; (2) effects of irrigation on agricultural production; and (3) methods of financing the large-scale collective irrigation enterprises.

History of Irrigation Investments

The history of controlled irrigation in Taiwan goes back to the fourteenth century (35). Statistically, however, it can be traced back only to the early 1900's.

ACREAGE IRRIGATED

On the basis of the summary data presented in Table 11, it is evident

Table 11. Irrigated Status of Cultivated Land, by Decenniums, from 1900 to 1960

Year	Arable land (hectare)	Double paddy (hectare)	Single paddy (hectare)	Dry land (hectare)
1900	347,409	194,657		152,752
1910	674,100	332,372		341,728
1920	749,419	246,484	120,693	382,242
1930	808,329	292,120	104,159	412,050
1940	860,456	324,209	205,412	330,835
1950	870,633	320,345	209,891	340,397
1960	869,223	329,053	196,527	343,643

Source: Taiwan Provincial Food Bureau, *Taiwan Food Statistics Book,* 1961, p. 1.

that irrigated land (double and single paddy) increased somewhat more rapidly from 1900 to 1960 than did total arable land. Until 1930, agricultural expansion was extensive—new lands were being developed more

rapidly than were irrigated lands (Table 12). The big increase in irrigated acreage took place in the 1930's with the completion of the huge Chianan irrigation development in the central-western part of the Island (See Chart 1). Most of this increase, however, was in single-paddy irrigation (due to the lack of water, each farmer in the Chianan system was restricted to single paddy once in three years). During the 1940's there was no net gain in irrigated acreage, and in the 1950's there was a net loss of 4,000 irrigated hectares, as well as a net loss of 1,000 hectares in total arable land.

Table 12. Changes in the Irrigated Status of Arable Land, from Decade to Decade, 1900–10 to 1950–60[1]

(Hectares-Thousands)

Decade	Arable land	Paddy land			Dry land
		Single	Double	Total	
From 1900 to 1910	+ 320			+ 130	+ 190
From 1910 to 1920	+ 70			+ 30	+ 40
From 1920 to 1930	+ 60	− 16	+ 46	+ 30	+ 30
From 1930 to 1940	+ 52	+ 100	+ 32	+ 132	− 80
From 1940 to 1950	+ 10	+ 4	− 4	0	+ 10
From 1950 to 1960	− 1	− 13	+ 9	− 4	+ 3

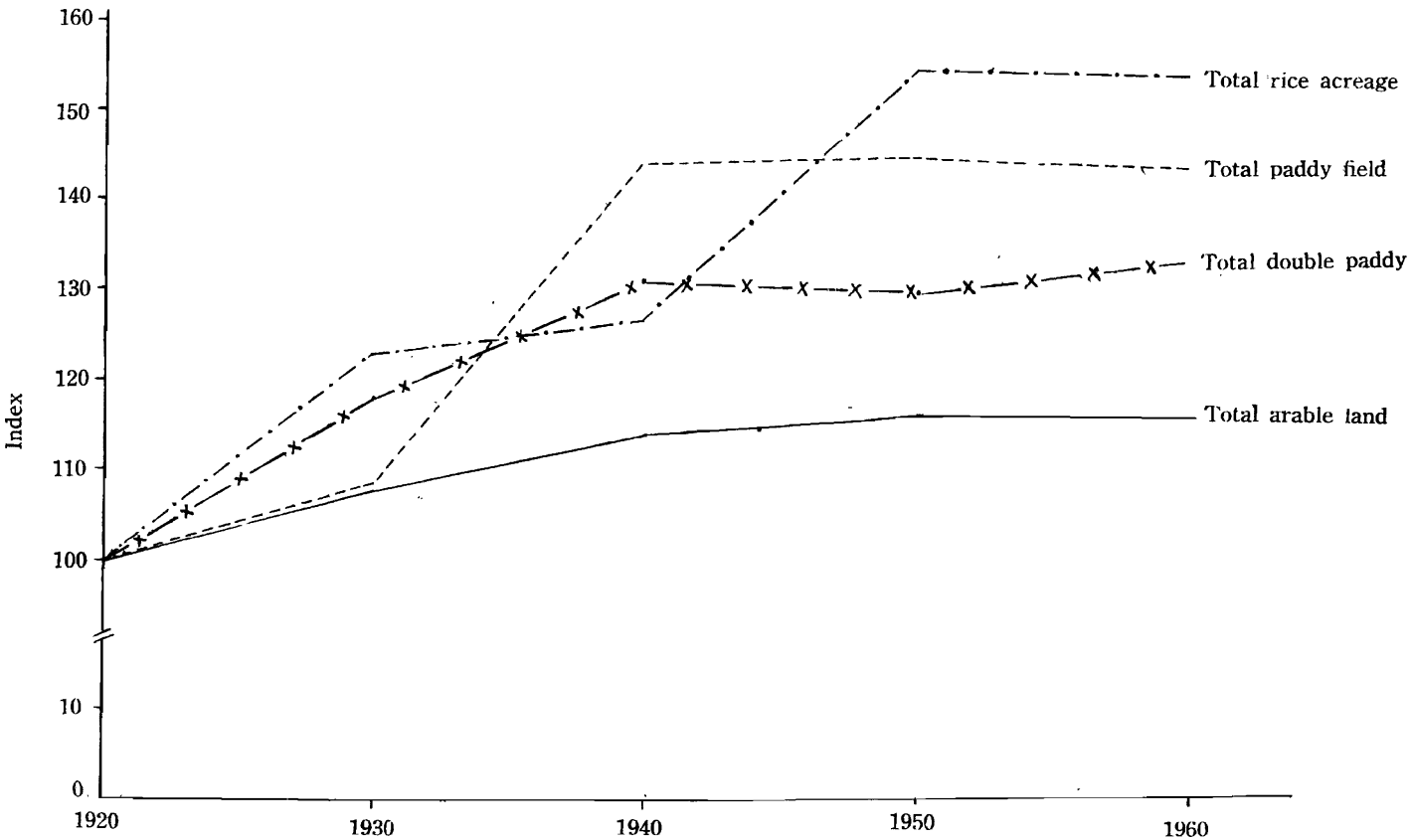
[1] Figures are rounded off to facilitate making comparisons.

Source: Table 11.

As of 1960, then, about 38 percent of all arable land was irrigated for double paddy, another 22 percent for single paddy, and 40 percent was in dry land. However, only 44 percent of the arable land and 73 percent of all paddy land was actually planted to rice (Table 13 and Chart 1), the basic staple food and irrigated crop in Taiwan. Sixty-three percent of all paddy land was classified as double paddy, but the acreage of rice plantings exceeded the acreage of double paddy by 16 percent.

In other words, in 1960, not all paddy land was used for rice production. However, a larger percentage of paddy land was used for rice in 1960 than in 1920 and 1940, a smaller percentage than in 1930, and about the same as in 1950. It appears that the slight transformation of single paddy and upland to double paddy between 1950–60 did not increase the amount of land planted to rice (Chart 1). Apparently, more and more of the double-and single-paddy land is being utilized for other crops than rice.

Chart 1. Changes in Amount of Arable, Paddy and Rice Land from 1920 to 1960
(1920=100)



Source: Table 13.

Table 13. Acreage of Arable Land Irrigated and Planted to Rice, by Decenniums, 1920–1960

	1920		1930		1940		1950		1960	
	ha.	per-cent	ha.	per-cent	ha.	per-cent	ha.	per-cent	ha.	per-cent
Total arable land	749,419	100	808,329	100	860,456	100	870,633	100	869,223	100
Total paddy field	367,177	49	396,279	49	529,621	62	530,236	61	525,580	60
Total double paddy	246,484	33	292,120	36	324,209	38	320,345	37	329,053	38
Acreage rice plantings	250,085	33	307,195	38	319,311	37	385,131	44	383,205	44
Percent double paddy of total paddy		67		74		61		60		63
Percent rice plantings of total paddy		68		78		60		73		73
Percent rice plantings of double paddy		102		105		98		120		116

Source: Taiwan Provincial Food Bureau, *Taiwan Food Statistics Book,* 1961, pp. 1 and 2.

If adequate water were available, all of the single-paddy land could be converted to double paddy which would mean a 60 percent increase in double paddy land. And, an estimated 70 percent of dry land could be converted to double paddy. In other words, approximately 88 percent of the arable land (assuming no change in the 1960 level of arable land) is eligible for double-paddy irrigation, which is an increase of 50 percent above the 1960 level* (36). (The maximum potential increase is 60 percent, as indicated in Table 7).

EXPENDITURES FOR IRRIGATION

Detailed statistics on the yearly expenditures for irrigation from 1901 to 1961 are presented in Appendix B, Tables B–1 and B–2. The first table covers the Japanese-occupation period and the second the post-Retrocession period from 1945 to 1961. The expenditure data separate investments by operational outlays (repair, maintenance, administration) and investments, and the source of investment funds by government and irrigation associations. The data are summarized by decades in Table 14. In order

* The water supply in Taiwan has been estimated at 88 billion cubic meters per year from rainfall, annual surface water of 36,663 mil. cubic meters, and a ground-water potential of 2,464,000 cubic meters. (These totals are not additive.) (37). Registered water rights for consumptive uses (excluding power) have claimed about 11 billion cubic meters of annual surface water and 600 million of annual ground water (38). However, only a small percentage of the water claimed is used. Engineers estimate that less than 5 percent of all water available is subject to controlled use, although all of the unregulated natural surface flow is being fully utilized (35).

Table 14. Investment and Operational Outlays for Irrigation, by Government and Irrigation Associations, and by Decades, 1901–10 to 1951–1960

(Current prices)

Decade	Investments			Operational outlays[1]	Total investment and operational outlays
	Government	Irrigation associations	Total		
1901–10	2,873,986	240,900	3,114,886	4,708,541	7,823,427
1911–20	7,699,866	798,200	8,498,066	16,143,890	24,641,956
1921–30	30,562,910	56,530,798	87,093,708	138,952,179	226,045,887
1931–40	8,193,228	18,006,443	26,199,671	98,855,852	125,055,523
1941–45[2]	35,219,558	15,042,892	50,262,450	119,318,344	169,580,794
1946–48[2]	—	1,840,593,538	1,840,593,538	12,361,867,489	14,202,461,027
1949–50[2]	449,694	14,219,906	14,669,600	75,783,971	90,453,571
1951–60	275,268,153	331,448,911	606,717,064	1,356,482,930	1,963,199,994

(1) Operational outlays are repair, maintenance and administration costs.

(2) 1945 is date of Retrocession; in 1948 changed from OT$ to NT$; in 1949–1950 had extreme price inflation.

Source: Appendix B, Tables B-1 and B-2.

to eliminate money value changes, the data are presented in real money terms in Table 15.

Table 15. Investment and Operational Outlays for Irrigation, by Government and Irrigation Associations, and by Decades, 1901–10 to 1951–1960

(Constant 1935–37 prices)

Decade	Total investments (Gov't. & irrigation associations) (OT$)	Operational outlays (OT$)	Total investment and operational outlays (OT$)
1901–10	6,229,772	9,417,082	15,646,854
1911–20	9,456,563	19,049,365	28,505,928
1921–30	81,765,447	131,437,646	213,203,093
1931–40	24,709,815	93,569,177	118,278,992
1941–50	19,860,851	50,091,051	69,951,902
1951–60	21,167,913	47,902,039	69,069,952

Sources: Price index data from monthly commodity-price statistics, Bureau of Accounting and Statistics, Provincial Government of Taiwan, Republic of China, and Table 14.

From the standpoint of reliability, the data have many limitations. First, private expenditures by farmers on irrigation facilities are missing. A rough approximation of what farmers have spent for irrigation may be gleaned from Table 16, which indicates that, as of 1955, farmers had provided self-installed irrigation facilities on about 12 percent of all irri-

Table 16. Cultivated Land Irrigated, by Source of Facilities, 1955

Source of facilities	Irrigated acreage (hectares)
Self-installed	59,304
Publicly-installed	416,126
Total	475,430

Source: Committee of Sample Census of Agriculture, Taiwan, China, *Report on the 1956 Sample Census of Agriculture,* August, 1959. p. 76.

gated hectares. These facilities include canals and private wells and pumps. As will be noted later, irrigation associations accounted for only about 90 percent of all irrigated acreage. Second, collective expenditures in the form of free labor-service spent on irrigation facilities and land donated for joint-irrigation enterprises are not accounted for*. Third, changing price levels, especially in the runaway inflation period of the 1940's, invalidate time-series comparisons. Fourth, of the investment amounts, no satisfactory allocation is available between new project investments and the amounts used to replace depreciated, destroyed, or obsolete facilities. Fifth, not all government expenditures on irrigation are accounted for. With these limitations in mind, we may note that the reported expenditures for irrigation, in constant dollars, reached a peak in 1928 and have remained far below since. Maintenance and repair expenditures were sharply curtailed in the 1930's. This neglect combined with bombing destruction in the 1940's created a great financial need in the 1950's to restore irrigation facilities to some level of adequacy. Throughout the 20-year period, 1940–1960, there was little expansion of irrigation facilities or irrigated acreage. The sharp rise in irrigation investments in the late 1950's is accounted for by the construction of the Ta-Pu Reservoir, Touliu Irrigation Canal, and the Shihmen Reservoir. Their full impact on irrigated acreage and agricultural output will not appear until the 1960's.

From the standpoint of economic feasibility, only the irrigation expenditures per hectare or per unit of increased output are of critical importance. Of these expenditures, the marginal cost of supplying water from new irrigation projects are the only significant costs. Such precise data are not available, however. In the first place, irrigated hectares are not homogeneous; some receive more irrigation water than do others, and

* The water law of the Republic of China permits the commandeering of land and labor for the execution of hydraulic construction works (39).

outputs attributable to irrigation are not easily ascertained. Secondly, the inability to accurately allocate investment outlays among past, present, and future outputs disqualifies the expenditure data for use in economic cost comparisons.

Two per hectare cost calculations are offered for comparative study. The first relates the operational cost per year per irrigated hectare (double and single paddy). (See Table 17.) The second indicates the investment in irrigation facilities relative to the increase in irrigated acreage per decade. (Some of the lags between investments and acreages irrigated are averaged out by comparing the data on a decade basis.) (See Table 18.)

Table 17. Operational Outlays per Hectare of Paddy Field, by Decades, 1901–10 to 1951–60

(Constant 1935–37 prices)

Decade	Operational outlays per hectare of paddy field (OT$)
1901-10	3.19
1911-20	5.58
1921-30	34.70
1931-40	19.40
1941-50	9.66
1951-60	10.00

Source: Appendix B, Tables B-1 and B-2.

Table 18. Average Irrigation Investment per Hectare of New Paddy Land, by Decades, 1901–10 to 1951–60

Decade	Investments		Increase in paddy land (ha.)	Average investment per ha. increased paddy land	
	(At current prices) (OT$ & NT$)	(At constant 1935–37 prices) (OT$)		(At current prices) (OT$ & NT$)	(At constant 1935–37 prices) (OT$)
1901-10	3,114,886	6,229,772	130,000	23.96	47.92
1911-20	8,498,066	9,456,563	30,000	283.27	315.22
1921-30	87,093,708	81,765,447	30,000	2,903.12	2,725.51
1931-40	26,199,671	24,709,815	132,000	198.48	187.20
1941-50	1,905,525,588	19,860,851	0	—	—
1951-60	606,717,064	21,167,913	− 4,000	—	—

Source: Appendix B, Tables B-1 and B-2.

The first set of data show decreased expenditures for operational purposes since the 1920's as irrigated hectares increased. A downward trend is to be expected because of the economics of larger-scale operations

but, as was noted above, part of the decrease since 1930 is due to inadequate charges and collections of water fees for maintenance, repair and administrative purposes.

The relationship between net hectares of irrigated land and investment is highly distorted and fails to conform to expectations. The expectations were that from decade to decade, real investment expenditures per hectare of newly irrigated land would increase, because the land easiest and least costly to irrigate would be irrigated first and the more costly last. Advancing from simple diversion dams to huge reservoirs should be more costly per irrigated hectare. The 1900 to 1940 data do meet expectations if the 1920 to 1940 data are combined, the average investment per hectare for that 20-year period was OT$ 657. Since 1940, the data fail to conform chiefly because investments in new projects are mixed with investments for replacement of old facilities, and hectares irrigated lag substantially behind new investments, particularly as investment outlays increase. (See time lag between beginning of construction and irrigation of the Ta-Pu project)

Projected Irrigation Investments

The irrigation projects underway and those proposed as of May 1962, are listed in Appendix C, Table C-1, with accompanying descriptive detail.

On the assumption that those projects for which estimates were available as of May 1962 will be completed by 1970, the total investment in expanded or improved irrigation facilities would amount to NT$ 6.6 billion. The total anticipated increase in rice production from the NT$ 6.6 billion investment is 580,742 metric tons. If realized, the increase would raise total production by 30 percent above the 1960 level of 1.9 million metric tons of brown rice.

The investment cost per metric ton of added rice, by individual irrigation projects, is shown in Table 19. The costs range from a low of about NT$ 3,200 per metric ton for ground-water pumping to a high of NT$ 23,076 for the Shihmen Dam project; the average of all projects is about NT$ 11,400. If priority of construction were based on costs per

Table 19. Estimated Cost of Irrigation per Metric Ton of Rice and per Hectare, by Major Water Resource Development Projects under Construction or Planning, May 1962

Project name	Cost per m/t of estimated increased rice production (NT$)	Cost per double-paddy—hectare (NT$)
1. Shihmen Irrigation	23,076	32,458
2. Tachia Irrigation	21,380	35,134
3. Paiho Reservoir	19,595	34,371
4. Tsengwen Reservoir	19,375	22,075
5. Houlung Reservoir	18,584	74,074
6. Canal Lining	10,714	2,431
7. Rotational Irrigation	6,275	6,343
8. Ground Water Pumping	3,199	5,396

Source: Appendix C, Table C-1.

metric ton of rice produced, the low-cost, high-yield projects ought to come first.

Prorating investment costs on a per hectare basis is difficult from the available data. The eight projects for which cost estimates are available are to provide new irrigation for approximately 80,000 hectares and to improve the irrigation on another 380,000 hectares. More than half of Taiwan's arable land would be affected by these irrigation projects, but not much more than 20 percent of the dry land would be converted to irrigated land. Most of the irrigation improvements are scheduled for the prefectures of Yunlin, Chiayi, Tainan and Kaohsiung which produce relatively small first-crops of rice due to the inadequacy of water (Table 20.) If all of the expected increase in rice production were grown on double-paddy land, the investment per hectare would range from NT$ 2,431 for canal lining to NT$ 74,074 in the Houlung Reservoir project. These investment costs are substantially above those incurred in earlier periods.*

When the investment in the several irrigation projects is tested in terms of their capital-output ratios, we may observe that they range from

* There is much criticism of the estimates of rice-production increases anticipated from irrigation investments; planned increases do not seem to materialize. It should be noted (1) that the post-Retrocession period has required abnormal amounts of deferred irrigation investments; (2) that the gestation period between irrigation investment and increased output is lengthening; and (3) land-use transformations are removing paddy land from rice to higher-value uses. Deliberate overestimation of benefits may occur in order to achieve a favorable benefit-cost ratio but this could be achieved by understating costs as well. The Ta-Pu Reservoir case study presented later highlights some of the problems of estimating costs and benefits.

Table 20. Rice Production Area and Yields, by Crops and Prefectures, 1960

Prefecture or city & crop		Production area (hectare)	Yields (Kg. per ha.)
Taipei Prefecture	1st	24,251	2,292
	2nd	20,870	1,950
Yilan Prefecture	1st	20,963	2,340
	2nd	19,982	2,151
Taoyuan Prefecture	1st	40,995	2,119
	2nd	38,451	2,117
Hsinchu Prefecture	1st	18,474	2,408
	2nd	17,120	2,449
Miaoli Prefecture	1st	17,994	2,478
	2nd	17,691	2,469
Taichung Prefecture	1st	28,010	2,848
	2nd	28,955	2,520
Changhwa Prefecture	1st	51,353	3,088
	2nd	52,454	2,547
Nantou Prefecture	1st	12,184	2,617
	2nd	14,827	2,192
Yunlin Prefecture	1st	17,103	3,089
	2nd	40,024	2,909
Chiayi Prefecture	1st	7,301	2,665
	2nd	30,598	2,472
Tainan Prefecture	1st	8,398	2,495
	2nd	48,073	2,334
Kaohsiung Prefecture	1st	17,452	3,200
	2nd	27,528	1,873
Pingtung Prefecture	1st	33,531	3,448
	2nd	42,528	1,872
Taitung Prefecture	1st	9,039	2,391
	2nd	8,801	2,459
Hwalien Prefecture	1st	10,221	2,003
	2nd	10,269	2,133
Taipei City	1st	1,149	2,495
	2nd	1,127	2,526
Keelung City	1st	668	1,774
	2nd	413	949
Taichung City	1st	6,279	2,883
	2nd	6,222	2,998
Tainan City	1st	210	2,758
	2nd	3,350	2,034
Kaohsiung City	1st	3,574	3,810
	2nd	3,547	2,218
Yangmingshan Administration	1st	2,323	3,176
	2nd	2,106	2,529
Taiwan: total	1st	331,472	2,719
	2nd	434,936	2,324

Source: Department of Agriculture and Forestry, Provincial Government of Taiwan, *Taiwan Agricultural Yearbook*, September 1961, pp. 35-36.

.88 (NT$ 3,199÷NT$ 3,640) for ground-water pumping to 6.3 (NT$ 23,076÷NT$ 3,640) for the Shihmen Dam project. The NT$ 3,640 is the farm net income per metric ton of rice. It is determined by applying a 65 percent net-income ratio to NT$ 5,600, the prevailing retail price of a metric ton of rice in Taipei, in early 1962.

In comparison, the average internal capital-output ratio in agriculture, excluding land, was estimated to be 2.42 in 1958 (Table 5). In industry, the average capital-output ratio (measured by dividing capital employed by the census value added) was 3.2 in 1959. In mining it was 1.0, in manufacturing 2.6, and in public utilities 10.5 (40).

Based on these comparisons, it appears that although many investments may yield higher returns per dollar invested than will irrigation, in comparison to other public utilities, irrigation investments are more profitable. Irrigation, like electric power, provides a utility that is necessary for the fuller utilization of other resources.

IMPACT OF IRRIGATION ON PRODUCTION

We noted earlier that irrigation has helped to accelerate the trend toward smaller-sized farms, which produces the dual effect of (a) increasing consumption of agricultural products on the farm, and (b) making capital formation in agriculture somewhat more difficult. On the other hand, irrigation has without question increased agriculture's gross output whether measured in total quantities produced by the multiple-crop index, or in real-value terms.

From the study of production statistics, it is apparent that rice production is dependent on irrigation and that the farmers' propensity to produce rice is extremely strong. Farmers seem to automatically turn to rice when adequate water becomes available.

Measuring the Impact.—Measuring the impact of irrigation on rice production is methodologically difficult because of the many other variables, such as weather, fertilizer, seed, labor efficiency, and price, that interact to influence total rice production. The difficulties of tracing cause and effect and in isolating determination factors are illustrated by a study of Charts 2, 3, 4. Depicted in the charts are the interrelationships between total rice production and its two major determinants: hectares planted to

rice and yield per hectare. The number of hectares planted to rice in turn is determined largely by (a) the amount of irrigated land; (b) the amount of water available and (c) the net returns from rice relative to that from other crops. The per hectare rice yield is affected by irrigation, fertilizer, pesticide, labor efficiency and management, and rice prices. Rice prices, in the short run, have a greater impact on the quality and quantity of fertilizer, pesticides and labor used than on the quality and quantity of irrigation employed. The rapid increase in rice prices after 1945 had a strong impact on both quantity of rice plantings, which responded to fertilizer applications and yields while irrigated acreage remained virtually stationary (Chart 4). However, there was an obvious shift of irrigated land from other crops, particularly sugar, to rice, especially between 1945 and 1950.

The results of multiple correlation analyses for the periods from 1922 to 1938 and 1950–60 between (1) planted rice acreage(A) as the dependent variable and irrigated hectares(I) and rice prices(P) as the independent variables, and (2) rice yields(Y) and fertilizer application(F), irrigated hectares and rice prices are shown below. A similar analysis of the 1938–1950 data is not attempted because of the abnormalities of that period.

(1) Period of 1922–38:

a. $A=40.68+0.7017I-0.0338\ P$ $R^2=0.9819$

$S_b=0.0863\ \ S_b=0.0668$ $S=4.371$

b. $Y=9.6196+0.2595F+0.6232I+0.0375\ P$ $R^2=0.9063$

$S_b=0.1240\ \ S_b=0.27735\ S_b=0.1109$ $S=5.3643$

(2) Period of 1950–60:

a. $A=107.7092+0.3954I-0.0017\ P$ $R^2=0.2234$

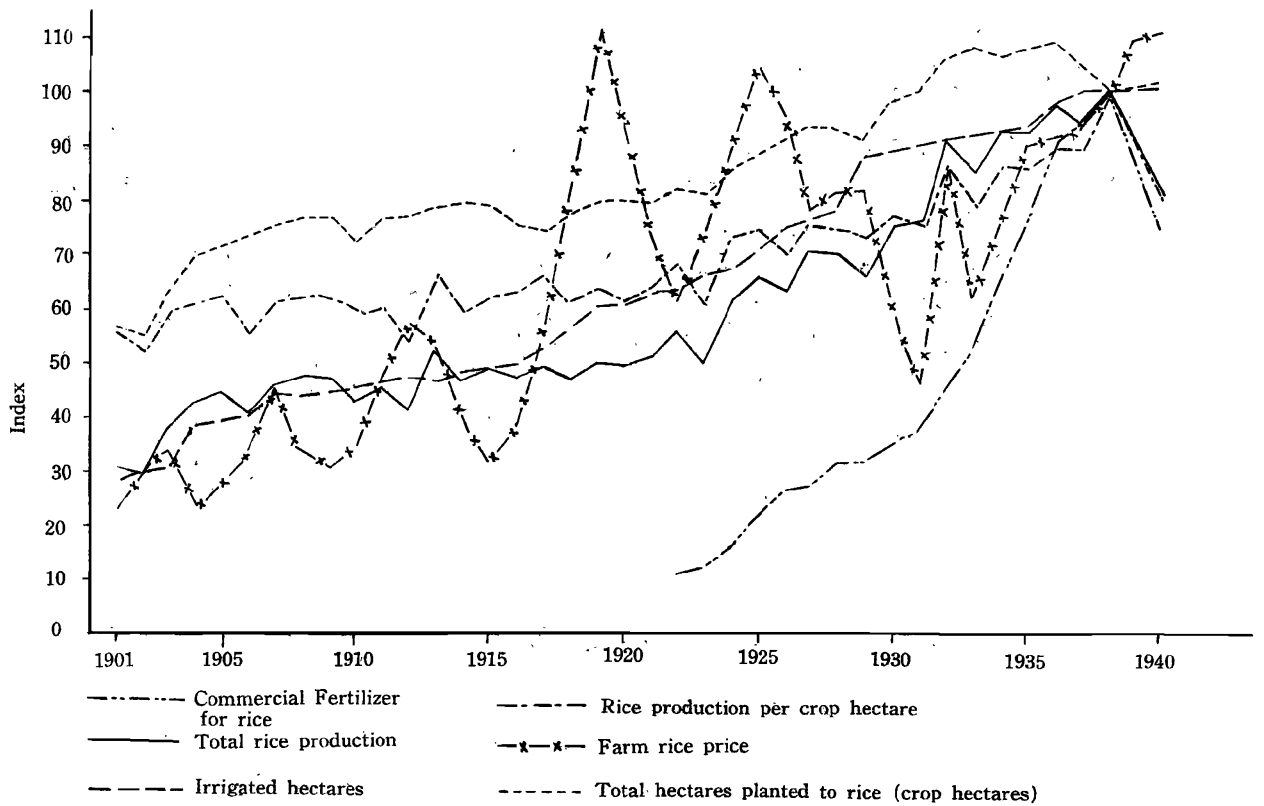
$S_b=0.3651\ \ S_b=0.0011$ $S=1.699$

b. $Y=-186.5523+0.4971F+2.4786I-0.0047\ P$ $R^2=0.97$

$S_b=0.7273\ \ S_b=0.6880\ \ S_b=0.0036$ $S=2.4918$

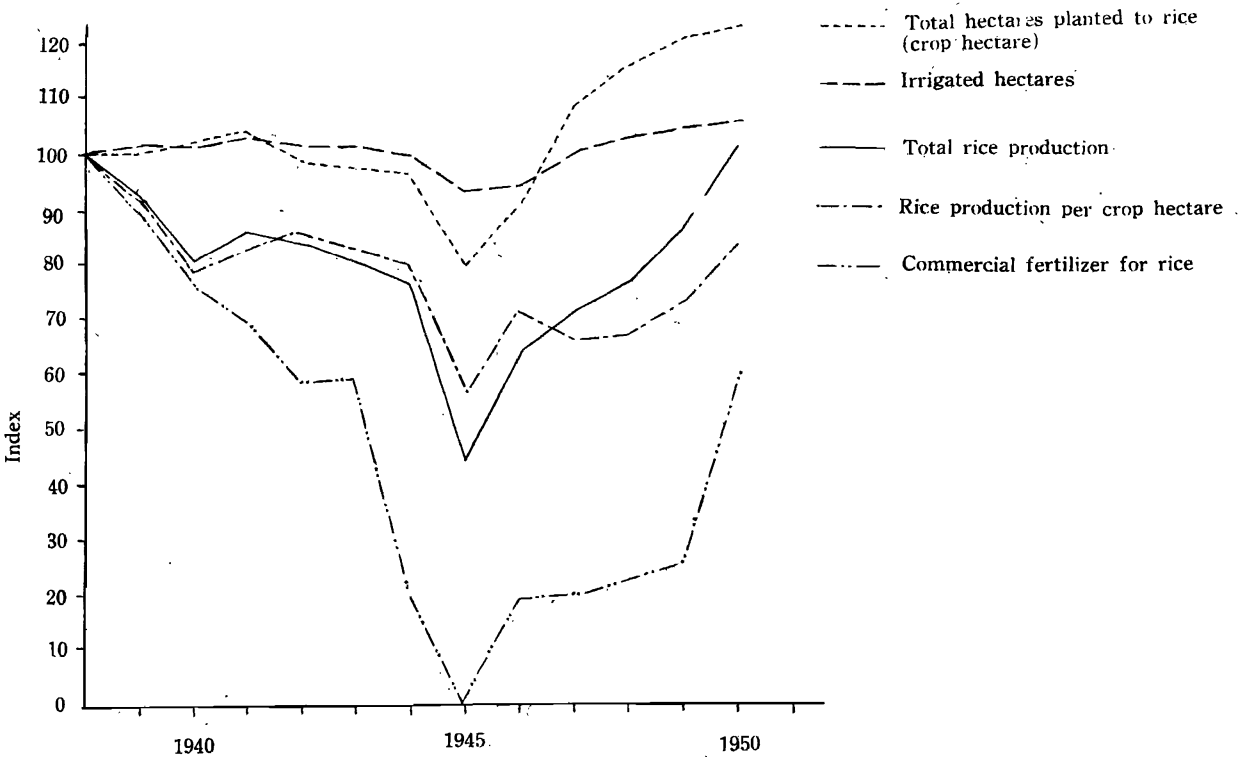
Except for equation (2a), the results of the multiple correlation analyses of the relationship between factors seems highly reliable as the determinant R^2 comes out larger than 0.9. In the period of 1922–38, the irrigated area has the same impact on the rice acreage as on yield. Price has no significant effect on the rice acreage or on rice yield. More than 60 percent of the increases in the rice acreage and yield in this period was related to the increase of irrigated area.

Chart 2. Rice Production Trends and Determinants, 1901–1940
(1938=100)



Source: Appendix D, Table D-1.

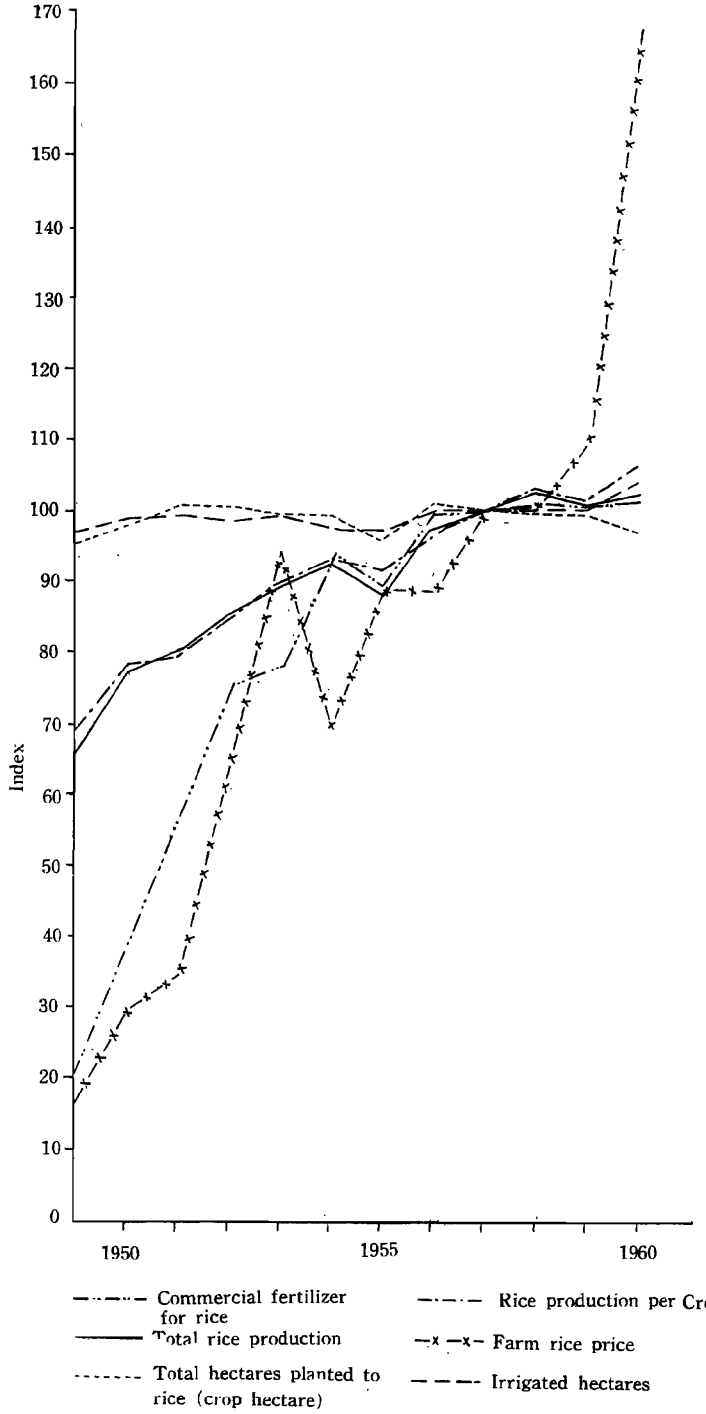
Chart 3. Rice Production Trends and Determinants, 1938–1950[1]
(1938=100)



[1] Farm rice price in this period was strictly controlled by government and it had no change with the supply and demand. So farm rice price was skipped from the Chart.

Source: Appendix D, Table D-1.

Chart 4. Rice Production Trends and Determinants, 1949–1960
(1957=100)



Source: Appendix D, Table D-2.

In the period of 1950–60, the irrigated area had a different effect on the rice acreage and yield than in the period of 1922–38. The irrigated area had a larger impact on the rice yield than on the rice acreage. These results reflect the greater multiple use of water in 1950–60 as compared to the pre-war period.

Impact on Land Values.—Land values provide more concrete evidence of the impact of irrigation than do correlation analyses. A special survey of land prices revealed that double-paddy land, on the average, had a value of about NT$ 52,000 more per hectare in 1960 than did single-paddy land and about NT$ 72,000 more than dry land (Table 21). Land values, theoretically, reflect discounted future net incomes. The value of double-paddy land largely reflects the increased net income that can be realized from land uses responding to irrigation.*

Table 21. Value of Land, by Irrigated Status, 1960

Type of land	Hectares (000)	Value (NT$000)	Value per Hectare (NT$)
Double paddy	329.1	50,037,022	152,042
Single paddy	196.5	19,805,628	100,792
Dry land	343.6	27,631,281	80,417

Source: *Statistics of Land Price,* unpublished report by Provincial Land Bureau, 1961.

The NT$ 52,000 spread between the present value of single-and double-paddy land can be realized if the net income per annum, compounded in perpetuity at 6 percent, is NT$ 3,120, or NT$ 6,240 if compounded in perpetuity at 12 percent. Applying the same technique to the NT$ 70,000 spread between paddy and dry land prices, the net income difference per annum must be NT$ 4,200 at 6 percent or NT$ 8,400 at 12 percent.

The land-price differential, then, is determined by two factors: (1) the net benefit from irrigation and (2) the discount rate of interest. The net benefit from irrigation varies from place to place and over time, as will be noted more clearly in the last two chapters. Lee estimated the

* Investment in land is motivated by other factors than future net incomes from agricultural uses. In a situation of economic insecurity and population pressures, land offers a fundamental security not available in other assets. Moreover, competition for land by higher value non-agricultural uses encourages the holding of land. We observe in the last chapter, however, that once water was assured in the Ta-Pu irrigation project, land values doubled and tripled virtually overnight.

following net benefits from irrigation, in terms of 1957 prices, for the ground-water development project to be as follows:*

Double paddy	NT$ 1,500 per hectare
Single paddy	NT$ 1,200 per hectare
Dry land	NT$ 1,700 per hectare

On the basis of these statistics, which are obviously low in terms of 1960 prices, the discount would have to be quite low to account for the 1960 land-price spreads of NT$ 52,000 and NT$ 70,000. The farmers' discount rate is variable and uncertain. According to Tsui's 1957 study of farm income, the average return on capital appeared to be about 8 percent (24). The capital-output ratio, including land, was about 7:1, which suggests a net return of land value—discount rate about 15 percent relative to capital used. We shall tackle the problem specifically in the Ta-Pu case study analysis.

Financing Irrigation Investments

If further and increasingly larger investments in irrigation can be justified, the next problem is how to finance such outlays. In order to answer this question, we should look first of all at the ways in which such investments have been financed in the past. Then, we can turn to alternative methods.

METHODS OF FINANCING

Returning again to Appendix B, Tables B-1 and B-2, we may observe the relative contributions of government and irrigation associations from 1901–1961. It is assumed that the government's aid from 1901 to 1950 was in the nature of grants and that government loans, if any, appear in irrigation association totals because they are subject to repayment. The amount of the funds invested by irrigation association coming from internal and external sources is unknown. The best information we can offer on this question is that presented in Table 22 for a period of three years, 1957, 1958 and 1960. From these data it appears that irrigation associations generated approximately 10 percent of their investment funds in these years. Only a few associations made new long-term investments in any one year.

* This study was made for the ground-water development project including the areas of Changhwa, Yunlin and Chiayi prefectures by the suggestion of International Development Association.

The amount of funds from different sources varies from association to association. The Liukong Irrigation Association, for example, (operating in the suburbs of Taipei City) derived more funds from the rental and sale of its real estate holdings than from water sales. Long-term loans exceeded by four times the amounts of special water fee collections in 1960.

The government's contribution to irrigation investments has varied widely in amounts and percentages over the years. Before Retrocession, irrigation investments seemed to rise and fall with the general world-wide business cycles (as reflected in Taiwan's rice prices shown in Chart 2). In general, when total irrigation investments were high the government's contribution was relatively low; irrigation associations resorted to their own resources or to loans. After Retrocession, and until 1958, the government's share in irrigation investment exceeded that of the associations. The investment statistics are deceptive, however. We are not certain as to how much of the investments are for replacement of old facilities and how much for investment in new facilities. Much of the government's help in the early 1950's went for maintenance and replacement purposes. The need for special repair funds, as noted earlier, indicates that the associations had not been collecting sufficient funds from their members for repair and maintenance purposes. Not until 1960 did such collections and disbursements appear reasonable (Table 22) and even then maintenance and repair expenditures amounted to only 1 percent of the value of fixed assets. (Table 24). If maintenance and repair expenditures were inadequate then it is reasonable to assume that the associations were not accumulating adequate depreciation reserves or new investment funds. Since each of the 26 Irrigation Associations are managed independently of each other, but according to prescribed government standards, we might profit from examining their operating statements. The latest available are for fiscal 1960.*

OPERATING STATEMENTS OF IRRIGATION ASSOCIATIONS

The water fees collected by the 26 irrigation associations in fiscal 1960 are shown in Table 23, as are hectares irrigated and the number of household memberships. The ordinary water fees, collected for administrative expenses, repair and maintenance, and reserves, far surpassed the special

* Admittedly, the statistics are of questionable reliability. The lack of a uniform accounting system, of qualified accountants, and of audited annual reports seem to be adequate reason for casting doubt on the statistics.

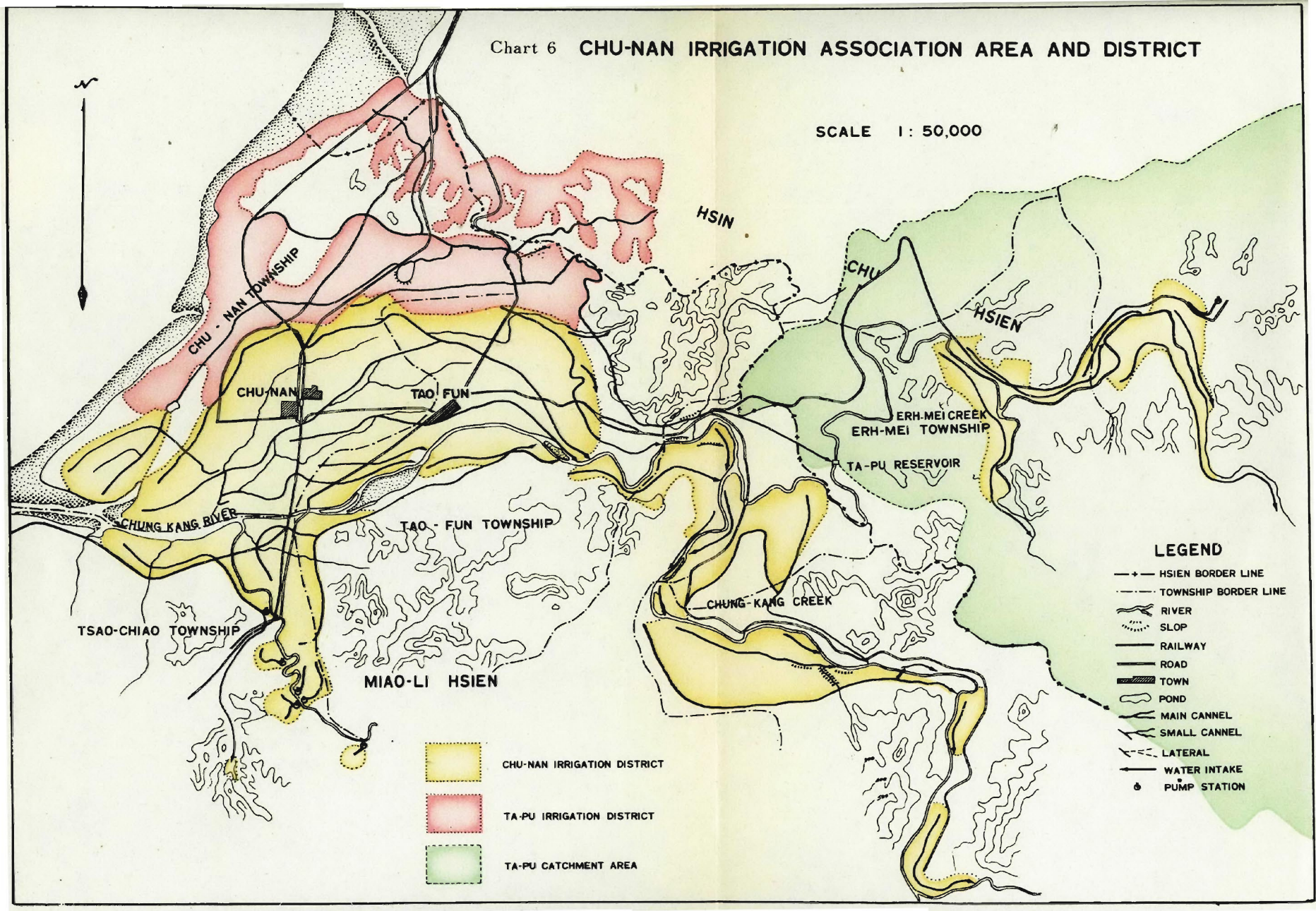


Chart 6 CHU-NAN IRRIGATION ASSOCIATION AREA AND DISTRICT
SCALE 1 : 50,000
HSIN CHU HSIEN
CHU - NAN TOWNSHIP
CHU-NAN
TAO FUN
ERH-MEI CREEK
ERH-MEI TOWNSHIP
TA-PU RESERVOIR
CHUNG KANG RIVER
TAO - FUN TOWNSHIP
CHUNG-KANG CREEK
TSAO-CHIAO TOWNSHIP
MIAO-LI HSIEN
CHU-NAN IRRIGATION DISTRICT
TA-PU IRRIGATION DISTRICT
TA-PU CATCHMENT AREA
LEGEND
HSIEN BORDER LINE
TOWNSHIP BORDER LINE
RIVER
SLOP
RAILWAY
ROAD
TOWN
POND
MAIN CANNEL
SMALL CANNEL
LATERAL
WATER INTAKE
PUMP STATION

Table 22. Receipts and Disbursements of All Irrigation Associations 1957, 1958 and 1960[1]

Receipts sources	1957		1958		1960[2]	
	NT$	%	NT$	%	NT$	%
Water fees	140,255,841.35	69.10	164,207,581.11	49.98	227,666,664.98	43.42
Property rents & sales	12,808,819.64	6.31	12,945,511.72	3.94	12,312,858.83	2.35
Subsidies	20,734,446.44	10.21	56,754,989.02	17.27	116,910,089.10	22.30
Long-term loan	7,977,899.53	3.93	69,142,188.65	21.04	134,612,948.16	25.67
Other receipts[3]	21,211,456.81	10.45	25,519,296.07	7.77	32,825,004.63	6.26
Total receipts	202,988,463.77	100.00	328,569,566.57	100.00	524,327,565.70	100.00
Disbursements:						
Operational	130,041,349.46	64.06	144,451,703.44	43.96	241,831,839.23	46.12
Administrative	57,755,662.17	28.45	67,395,608.60	20.51	81,738,982.27	15.59
Maintenance & repair	72,285,687.29	35.61	77,056,094.84	23.45	160,092,856.96	30.53
Investment	56,894,275.86	28.03	141,331,551.38	43.02	181,679,748.30	34.65
Reserve funds	—	—	—	—	50,438,248.88	9.62
Loan repayment	17,726,026.82	8.73	23,461,141.17	7.14	21,075,859.30	4.02
Total disbursement	204,664,652.14	100.82	309,244,395.99	94.12	495,025,695.71	94.41
Balance:	— 1,676,188.37	— 0.82	19,325,170.58	5.88	29,301,869.99	5.59

(1) Fiscal years ending June 30.

(2) The 1960 figures follow the 1958 figures. The fiscal year date was advanced one year to match the government's fiscal year.

(3) Includes interest income, surplus above book value of fixed assets, sale of bonds and stocks, sale of materials and collections from employees for retirement fund.

Source: "Financial Study of Irrigation Association, 1957-59", unpublished, Joint study by Provincial Water Conservancy Bureau and Joint Commission on Rural Reconstruction.

water fees collected for the repayment of loans. Operational expenditures (Table 22) exceeded the total ordinary water fee collections. Ordinary fee collections, on the average, were only 83 percent of assessments, and ranged from 29 percent in the Nunkao association to 97 percent in the Chianan association. The unfavorable collections are attributed largely to the added NT$100 per hectare assessment in 1959 for a joint construction fund reserve (Tables 23 and 26). For unexplainable reasons, the irrigation associations had a poorer collection experience with special water fees.

In spite of their good payment record in fiscal 1960, farmers, in the aggregate, owed about a year's water fees on June 30, 1960, as reflected by the accounts receivable position of all irrigation associations, (Table 24). The balance-sheet statement indicates the asset-liability position of all associations. In general, the current and funded assets were low relative to total liabilities, and the funded reserves were low relative to the value

Table 23. Water Fee Assessments and Collections, by Irrigation Association in 1960[1]

Irrigation association	No. of irrigated area (ha.)	No. of farm households belonging to association	Total water fees assessed NT$			Assessed fees collected	
			Ordinary	Special	Total	Ordinary (percent)	Special (percent)
Yilan	22,797	27,137	9,047,343.00	296,736.10	9,344,079.10	61.66	91.70
Keelung	6,639	8,469	759,416.37	—	759,416.37	31.00	—
Tamsui	5,728	5,378	996,911.90	—	996,911.90	39.00	—
Chihsing	2,674	4,376	1,630,432.70	—	1,630,432.70	63.32	—
Liukong	3,184	8,824	901,456.80	—	901,456.80	45.41	—
Hsinhai	6,949	10,029	3,331,685.50	—	3,331,685.50	65.00	—
Taoyuan	28,458	26,346	15,285,260.00	437,500.00	15,722,760.00	72.53	—
Chungli	3,874	5,068	985,714.86	12,185.63	997,900.49	53.05	51.85
Hsinchu	10,648	17,475	5,171,071.50	413,081.60	5,584,153.10	77.09	76.85
Chunan	5,173	9,787	1,882,045.70	246,798.60	2,128,844.30	75.60	66.50
Miaoli	5,934	9,949	2,635,775.00	148,352.00	2,784,127.00	85.26	95.00
Wanli	5,980	8,759	1,883,011.10	—	1,883,011.10	68.00	—
Dachia	12,037	18,546	5,593,286.10	48,782.60	5,642,068.70	89.60	88.22
Houli	5,018	6,031	2,451,900.10	—	2,451,900.10	95.80	—
Fonzon	21,817	35,894	10,402,487.50	—	10,402,487.50	72.60	—
Nantou	7,839	16,408	3,760,368.70	50,527.00	3,810,895.70	99.57	89.67
Nunkao	5,885	12,700	1,709,733.90	227,096.60	1,936,830.50	29.40	32.20
Changhwa	51,825	126,146	28,119,987.80	2,288,879.20	30,408,867.00	74.09	23.84
Chushan	4,242	8,679	1,817,007.60	71,355.50	1,888,363.10	68.00	68.70
Touliu	20,159	23,134	8,775,167.90	5,046,571.10	13,821,739.00	94.11	95.97
Chianan	149,287	331,734	53,725,164.40	15,207,719.12	68,932,883.52	96.82	95.93
Kaohsiung	24,734	32,454	11,988,056.70	3,784,412.10	15,772,468.80	94.51	95.24
Pingtung	41,154	45,399	15,098,542.60	4,341,530.60	19,440,073.20	90.00	77.00
Taitung	5,101	5,143	1,973,024.50	—	1,973,024.50	93.00	—
Hualien	10,968	12,969	3,518,306.20	469,535.80	3,987,842.00	34.82	18.32
Hsinkang	3,627	3,464	1,132,443.00	—	1,132,443.00	74.93	—
Total	471,731	820,298	194,575,601.43	33,091,063.55	227,666,664.98	82.51	86.12

(Continued)

Table 23 (Continued)

Irrigation association	Water fees assessed per household NT$			Water fees per hectare NT$/Ha		
	Ordinary	Special	Total	Ordinary	Special	Total
Yilan	333.40	10.93	344.33	396.86	13.02	409.88
Keelung	89.67	—	89.67	114.39	—	114.39
Tamsui	185.37	—	185.37	174.04	—	174.04
Chihsing	372.59	—	372.59	609.74	—	609.74
Liukong	102.16	—	102.16	283.12	—	283.12
Hsinhai	332.21	—	332.21	479.45	—	479.45
Taoyuan	580.17	16.61	596.78	537.12	15.37	552.49
Chungli	194.50	2.40	196.90	254.44	3.15	257.59
Hsinchu	295.91	23.64	319.55	485.64	38.79	524.43
Chunan	192.30	25.22	217.52	363.82	47.71	411.53
Miaoli	264.93	14.91	279.84	444.18	25.00	469.18
Wanli	214.98	—	214.98	314.88	—	314.88
Dachia	301.59	2.63	304.22	464.68	4.05	468.73
Houli	406.55	—	406.55	488.62	—	488.62
Fonzon	289.81	—	289.81	476.81	—	476.81
Nantou	229.18	3.08	232.26	479.70	6.45	486.15
Nunkao	134.63	17.88	152.51	290.52	38.59	329.11
Changhwa	222.92	18.14	241.06	542.60	44.16	586.76
Chushan	209.36	8.22	217.58	428.34	16.82	445.16
Touliu	379.32	218.14	597.46	435.30	250.34	685.64
Chianan	161.95	45.84	207.79	359.88	101.87	461.75
Kaohsiung	369.39	116.61	486.00	484.68	153.00	637.68
Pingtung	332.57	95.63	428.20	366.88	105.49	472.37
Taitung	383.63	—	383.63	385.10	1.69	386.79
Hualien	271.29	36.20	307.49	320.78	42.81	363.59
Hsinkang	326.92	—	326.92	312.23	—	312.23
Average	237.19	40.35	277.54	412.47	70.15	482.62

(1) Fiscal year ending June 30, 1960.

Source: Provincial Water Conservancy Bureau.

Table 24. Balance Sheet, All Irrigation Associations

June 30, 1960

Assets				Liabilities			
Current assets:				Current liabilities:			
	Cash on hand	NT$	58,656,477.26		Accounts payable	NT$	94,312,439.11
	Accounts receivable		201,039,370.97		Prereceived		1,167,520.20
	Bonds		190,990.64		Temporary credits		7,837,424.00
	Commodities		6,846,083.89		Consigned payable accounts		1,106,582.56
	Guarantee deposits paid		1,312,615.19		Short-term borrowing		33,296,298.34
	Prepaid		57,917,612.69		Guarantee deposits received		289,250.54
	Accounts in advances		14,286,087.94			NT$	138,039,514.75
	Materials		14,586,517.73	Fixed liabilities:			
	Note receivable		3,840.296.45		Long-term borrowing		95,425,284.71
		NT$	358,676,052.76		Special borrowing		165,710,884.80
Funds:						NT$	261,136,169.51
	Reserve for depreciation	NT$	808,589.07				
	Reserve for damage		23,874,250.88	Total liabilities		NT$	399,175,684.26
	Reserve for employees'retirement		169,357.99				
	Irrigation construction fund		13,748,795.86				
	Land price repayment		107,186.82				
		NT$	38,708,180.62				
Fixed assets:							
	Assets and installation		949,369,148.78				
	Unfinished projects		89,778,104.95				
		NT$	1,039,147,253.73	Net worth:		NT$	1,037,355,802.85
Assets:		NT$	1,436,531,487.11	Liabilities and net worth		NT$	1,436,531,487.11

Source: Provincial Water Conservancy Bureau.

Table 25. Irrigation Associations' Indebtedness, by Associations and Hectares, 1960[1]

Unit: NT$

Irrigation associations	Hectares	Current liabilities		Fixed liabilities		Total liabilities	
		Total amount	Average per ha.	Total amount	Average per ha.	Total amount	Average per ha.
Yilan	22,797	1,910,871.31	83.82	575,250.75	25.23	2,486,122.06	109.05
Keelung	6,639	1,024,205.93	154.27	359,875.17	54.21	1,384,081.10	208.48
Tamsui	5,728	1,352,434.36	236.11	699,250.00	122.08	2,051,684.36	358.19
Chihsing	2,674	1,459,378.48	545.76	160,000.00	59.84	1,619,378.48	605.60
Liukong	3,184	7,792,505.80	2,447.40	—	—	7,792,505.80	2,447.40
Hsinhai	6,949	1,025,431.01	147.56	75,522.30	10.87	1,100,953.31	158.43
Taoyuan	28,458	1,732,802.57	60.89	8,249,629.99	289.89	9,982,432.56	350.78
Chungli	3,874	696,107.66	179.69	58,072.80	14.99	754,180.46	194.68
Hsinchu	10,648	808,334.82	75.91	236,281.29	22.19	1,044,616.11	98.10
Chunan	5,173	608,210.07	117.57	28,168,993.17	5,445.39	28,777,203.24	5,562.96
Miaoli	5,934	1,011,041.62	170.38	2,317,916.17	390.62	3,328,957.79	561.00
Wanli	5,980	629,624.87	105.29	819,779.49	137.09	1,449,404.36	242.38
Dachia	12,037	226,037.61	18.78	2,017,119.26	167.58	2,243,156.87	186.36
Houli	5,018	90,941.40	18.12	311,000.00	61.98	401,941.40	80.10
Fonzon	21,817	8,966,406.00	410.99	5,349,854.60	245.21	14,316,260.60	656.20
Nantou	7,839	371,946.44	47.45	3,801,794.53	484.98	4,173,740.97	532.43
Nunkao	5,885	1,342,526.63	228.13	3,737,033.26	635.01	5,079,559.89	863.14
Changhwa	51,825	55,383,832.62	1,068.67	47,326,532.31	913.20	102,710,364.93	1,981.87
Chushan	4,242	208,328.90	49.11	1,014,459.47	239.15	1,222,788.37	288.26
Touliu	20,159	7,293,871.67	361.82	32,513,898.95	1,612.87	39,807,770.62	1,974.69
Chianan	149,287	13,365,767.83	89.53	95,755,318.27	641.42	109,121,086.10	730.95
Kaohsiung	24,734	8,810,050.77	356.19	5,853,958.65	236.68	14,664,009.42	592.87
Pingtung	41,154	12,477,050.79	303.18	15,139,940.58	367.88	27,616,991.37	671.06
Taitung	5,101	3,912,734.54	767.05	—	—	3,912,734.54	767.05
Hualien	10,968	5,383,859.45	490.87	6,594,688.50	601.27	11,978,547.95	1,092.14
Hsinkang	3,627	155,211.60	42.79	—	—	155,211.60	42.79

(1) Fiscal year ending June 30, 1960.

Sources: Appendix E, Table E-1, and Provincial Water Conservancy Bureau.

of fixed assets. Inasmuch as no recent inventory of irrigation association assets is available, the value of fixed assets and net-worth position indicated in Table 24 must be viewed with skepticism. Without some estimate of the value and life of major facilities, it is highly unlikely that adequate funding provisions were being made for the replacement and repair of existing facilities, or for the financing of new investments.

The liability amounts of Irrigation Associations, added to agriculture's total liabilities shown in Table 1, would increase the latter by less than 5 percent. Farmers' debt for irrigation, as of 1960, was rather infitesimal in relation to its value.

PROBLEMS OF FINANCING NEW INVESTMENTS

According to the Republic of China's water laws, no specific provisions or alternatives are provided for the financing of irrigation investments. A basic requirement is that special costs incurred are to be paid by the beneficiaries and ordinary fees are to be the same per hectare for all members of an association. That these two fees vary in amounts on a per hectare or per member basis by associations is made quite obvious in Table 23. The reasons for the variations are numerous but our chief concern here is with the financing of new investments.

An association has two methods available, exclusive of government subsidy, of acquiring investment funds. The first method is to accumulate funds in advance. These funds may be depreciation funds and/or special assessments that are accumulated at interest. As we have noted above, associations' depreciation reserves were low in 1960. As we will note later, special assessments have been imposed since 1955. The second method, which may be employed in combination with the first, is to borrow money and to repay it from future assessments. (Theoretically, from increased earnings attributable to the investment). This method, plus subsidies, has been the traditional method.

We may observe in Table 23 that special water fees collected amounted to only NT$ 33 million in fiscal 1960 (assessments were about NT$ 40 million). The collections were to partly repay some NT$300 million of short-and-long-term borrowings outstanding as of June 30, 1960 (Table 24), which suggests a pay-off of the amount due in about 10 years. The indebtedness on a per hectare basis by associations, as of June 30, 1960, is reported in

Table 25, and in total amounts in Appendix E, Table E-1. The current liabilities ranged from NT$ 18.12 per hectare in the Houli Association to NT$ 2,447 in the Liukong Irrigation Association. The fixed indebtedness ranged from zero in three associations to a high of NT$ 5,440, which was far above all others, in the Chunan Association, the parent association of the Ta-Pu-reservoir case-study area. The fixed indebtedness falls on only the farmers benefiting from investments outstanding and not on all association members. For example, the indebtedness in the Chunan area falls on only about 30 percent of the total irrigated area.

How much of the Associations' borrowings came from government and how much from private sources is not known. Because of the 6 percent rates prevailing on government loans until 1960 it is assumed that the nearly all long-term borrowings were from government sources. It was suggested earlier, and the thought will be developed more fully later, that more long-term financing can be provided within the Associations themselves for lending to investing associations.

IRRIGATION INVESTMENT FUNDS

Government authorities have long recognized the need for Irrigation Associations to generate more investment funds and in advance of their need. Since 1955, two special funds have been established and a third nearly reached fruition. The established funds are: (1) the joint revolving funds, and (2) the joint construction fund. An irrigation development fund was approved by the Legislative Yuan but not adopted.

Joint Revolving Fund.—This fund, administered by the Joint Council for Irrigation Associations, was accumulated for urgent repairs and rehabilitation, as verified by the Provincial Water Conservancy Bureau. Collections started in 1955 and were continued for the statutory limit of five years. All Irrigation Association members paid an added NT$ 20 per hectare per year ordinary water fee into the fund. The monies collected were deposited in the Land Bank at 1.20 percent monthly and loaned to Irrigation Associations in need, as short-term loans, at 1.4 percent per month (13). On June 30, 1960, nearly NT$ 24 million was in the fund, (Table 24) and by May 1962, NT$ 65 million was available for lending on a revolving basis.

Joint Construction Fund.—The joint construction fund was begun in 1959 for the purpose of accumulating monies for large-scale repair, rehabilitation and improvement projects. The monies collected are held by the Provincial Conservancy Bureau. Collections by May 1962 amounted to NT$ 125.3 million. The assessments, included in the ordinary water fee, averaged about NT$ 125 per hectare per year.

The net effect of the increased water fees was that on the average farmers paid about 50 percent more ordinary water fees in 1959–60 than they did in 1958 (Table 22).

Irrigation Association members are to contribute different amounts into the fund depending on the type of land farmed (Table 26). Paddy farmers contribute more than do dry-land farmers which tends to equalize water payments between the farmers benefiting from earlier low-cost projects (mostly in the north) and those yet to obtain water from higher-cost projects (mostly in the south).

Table 26. Percentage of Ordinary Water Fees Before and After Adjustment, by Type of Income and Benefits and by Type of Land[1]

	Type of income and benefits	Ordinary water fee (percents)				
		Double-paddy land	Single-paddy land	3-year-rotation land	2-year-rotation land	Average
Before adjustment of water fees 1958	Gross farm income	1.72	2.39	3.26	1.38	2.35
	Net farm income	13.89	12.50	11.90	19.61	12.57
	Irrigation benefits	22.27	33.47	28.87	35.52	26.10
After adjustment in 1959	Gross farm income	2.87	3.25	4.24	1.46	3.39
	Net farm income	23.13	17.16	15.44	20.74	18.07
	Irrigation benefits	37.06	45.95	37.47	37.56	37.55

(1) Based on a sample of six Irrigation Associations.
Source: "A Study on Financial Position and Water Fee Collection of Irrigation Association." JCRR and PWCB, July 1960, p. 3 (In Chinese).

After the fee increase, farmers on double-paddy land were required to pay 66 percent more than before as contrasted to only 37 percent for farmers on single-paddy land, 30 percent for farmers on 3-year rotation land, and 6 percent for occupants of 2-year-rotation land. All but single-paddy farmers were expected to pay 37 percent of the total benefits,

attributable to irrigation, as ordinary water fees. Single-paddy farmers were to pay 46 percent of their irrigation benefits. Even so, the per hectare ordinary water fees after adjustment averaged only NT$ 412, ranging from a low of NT$ 114 in the Keelung Irrigation Association to a high of NT$ 610 in the Chihsing Association (Table 23). Ordinary water fees remained far from equal in Taiwan.

If the irrigable benefits stated in Table 26 are correct, the full benefits from irrigation were estimated to approximate NT$ 1,333 per hectare in 1959. There is reason to believe that these irrigable benefits are too low. In the next section we show that some farmers in Southern Taiwan paid as much as NT$ 6,600 per hectare per year for water.

The Irrigation Associations receive 5.5 percent per annum on the monies paid into the fund. The interest earned is credited to each Association's account with PWCB. No interest is earned by the contributing farmers. Fund balances are maintained in the Land Bank which has the unused monies available for its own short-term lending.

By May 1962, some NT$ 56.7 million in loans had been made from the fund. Loans may be for as long as 15 years. The lending rate to borrowing associations is 6 percent per annum.

It is reported that farmers object to this fund on two counts. First, they receive no interest return on their contributions. Second, the 6 percent lending rate is too low especially when the private money market asks 18 percent or more for similar loans.*

At the time the joint construction fund was established, a larger irrigation development fund was visualized to meet the investment needs of large-scale irrigation projects.

Irrigation Development Fund.—As originally proposed, the irrigation development fund was to be a revolving fund accumulated at the rate of NT$ 280 million for five years, and financed from five sources: (1) all

* This type of subsidization of benefited farmers by non-benefited farmers seems not to be covered or anticipated by the water law which requires farmers to pay the full direct costs of all irrigation investments from which they benefit. The principles of equity and economy suggest that farmers ought to earn at least a nominal rate of interest on their contributions to the fund. An interest return appears essential if more irrigation investment funds are to be obtained from farmers.

repayments of government loans by Irrigation Associations (about NT$ 60 million yearly) were to be diverted to the fund; (2) the Taiwan Provincial Government was to add its normal allocation of about NT$ 80 million yearly; (3) the U. S. government was to contribute NT$60 million annually; (4) the Taiwan Food Bureau was to add NT$ 40 million; and (5) farmers and Irrigation Associations were to be responsible for the balance of NT$ 40 million in the form of labor and local materials.

Borrowers were given two options for repayment. One was in rice at the price prevailing when the contract was signed and at a zero rate of interest. The other was in cash at an interest rate of 12 percent per annum. The maximum term of loan was to have been 20 years.

The plan foundered chiefly because of the lack of agreement among the contributors and the failure to implement the fund with monetary contributions.

In spite of its defects, the plan had its merits. It would have established a specific budget amount for investments, and new projects would have had to compete for funds on the basis of profitability or rate of return. In retrospect, it appears that the fund hardly would have been adequate to meet the NT$ 6.6 billion budgeted for irrigation in the 1960 decade. To finance NT$6.6 billion would require at least a NT$500 million annual accumulation for five years and a NT$2.5 billion revolving amount, if 20-year loan maturities were the rule.

Provision could have been made for greater contributions to the revolving fund from the Irrigation Associations and the Food Bureau. A NT$ 500 annual per hectare assessment on Irrigation Association members for five years would have provided nearly NT$ 250 million annually or about half of the needed revolving fund. There is reason to believe, that if farmers were paid a reasonable interest rate for monies contributed to an irrigation investment fund they could provide an adequate revolving fund without government contributions. In view of the large annual profits to the Food Bureau from the rice-price spread and fertilizer sales, it should have been called on for more than a NT$ 40 million annual contribution to the irrigation development fund.

The rapid increase in the joint construction fund, without government contributions and only nominal delinquencies, indicates that the irrigation

associations are capable of generating substantial quantities of their own investment capital requirements.

IDA COOPERATIVE LOANS

After the collapse of the investment fund proposal, special financial arrangements were made with the International Development Association for the long-term financing of the high-yielding ground-water development projects (41). In August 1961, IDA loaned US$ 3.7 million to the Republic of China of an eventual total investment that would amount to NT$ 457 million (US$ 11.4 million equivalent) for the construction of 765 irrigation wells. The Provincial Government is to subsidize the total cost of the ground-water project by 60 percent. The balance will be on a loan basis from the Republic of China (IDA loan) and the Joint Commission on Rural Reconstruction. The IDA loan to the Republic of China bears no interest but the principal is to be repaid in U. S. dollars within 40 years. The loans to the farmers are to be repaid in 20 years and bear an interest rate of 12 percent per annum.

ALTERNATIVE METHODS OF FINANCING

Rather than imposing additional assessments on irrigation association members or borrowing from government or other lenders, and alternative method of financing would be to allow the Associations, or the Joint Council for Irrigation Associations, to issue revenue bonds to the general public. Revenue bonds would provide not only for external financing but also a market test of the quality of bonds and of the proposed project. The interest rate could either be predetermined, allowing the price of the bonds to fluctuate so as to determine the real interest rate, or the initial price of the bonds could be fixed and the bidders would bid the interest rate to be paid by the Associations. A reliable and extensive bond marketing system would be needed to assure competition among bidders and sales to investors. In order to sell the bonds and at the lowest rates possible, investors would need assurance that the bonds would be redeemed on schedule. To provide such assurance, the issuing body would need to have stronger fee-collection powers, such as shutting off water or obtaining a mortgage in the land, which irrigation associations do not now possess.

On the other hand, the revenue bonds might be sold to individual Irrigation Associations, credit cooperatives, and farmers' associations thereby

eliminating the necessity for public sale and for a well-developed private marketing system. Such sales could no doubt be made at less cost and lower interest rate to farmers' financial institutions than if the bonds were marketed to the public. As was pointed out earlier, Taiwan's agriculture has adequate resources and credit capacity for financing most of its own capital development. It appears incongruous to be asking agriculture to help finance industrial development while at the same time to be diverting funds from industrial development to the use of agriculture. The major obstacle to agriculture's internal financing is the lack of organized institutional arrangements that are conducive for the accumulation of investment capital and for the collection and repayment of amortization funds.

Summary

New irrigation investments were at a virtual standstill between 1930 and 1960; irrigated acreage increased at a decreasing rate and absolutely after 1950.

An upsurge of investments took place in the late 1950's but their impact will not be felt until the 1960's. Government has subsidized irrigation investments liberally. Irrigation Associations assumed greater responsibility for their own investments in the late 1920's and again after 1959.

Irrigation has a decided impact on the production of certain types of crops, notably rice. Although farmers spent nearly four times as much for fertilizer than for water in 1960, irrigation is fundamental to the expanded use of fertilizer and other resources. Its impact can be most precisely measured in terms of land-price increases.

Little self-financing of investment needs has been undertaken by Irrigation Associations. Most investments are taken care of by government subsidies or loans, the latter mostly at an interest rate of 6 percent per annum and amortized in 10 years or less.

The Associations have much greater capacity for self-financing than they have utilized. The debts of farmers and Irrigation Associations are low. If farmers were paid a reasonable rate of return, they would likely contribute more monies to self-financing arrangements. Numerous alternative methods to borrowing and subsidies are available for irrigation-invest-

ment financing, namely, a self-financed revolving fund and revenue bonds. The large capital needs of proposed irrigation projects suggest that new methods be employed to divert agriculture's surplus capital funds into such investments.

CHAPTER IV

ECONOMIC FEASIBILITY, PRIORITY AND REPAYABILITY OF IRRIGATION PROJECTS

We observed in the preceding section that Taiwan's irrigation development, as measured by irrigated acreage, is well advanced. Financial commitments for new water projects will carry total area irrigated to about 60 percent of the potential. An economic analysis of Taiwan's irrigation feasibility, priority, and repayability is somewhat belated and historical experience may suggest that it is unneeded. Irrigation is vital to Taiwan's intensive agriculture and food production and her population pressure gives little pause for economic direction-finding and guidance.

Although feasibility and priority, to be treated in this section, are no longer of concern for committed projects they are of concern for the few remaining proposed projects. Repayability, however, is of serious importance for the committed, proposed, and some of the completed projects not yet repaid. Moreover, the criteria discussed and proposed herein have applicability for other water-development investments, such as cloud-seeding or sprinkler irrigation, and for other types of industrial, agricultural, and governmental investments.

Economic Feasibility

The economic feasibility of a project implies that its total returns will equal or exceed its total costs during the economic life of the investment. The principle is simpler than its application. Before attempting to compute feasibility, it appears wise to clarify some concepts that are central to the issue of determining a rate of return on investment.

CLARIFICATION OF CONCEPTS

The concepts needing clarification are the principal components of the feasibility formulas. Significant differences exist between the following concepts: economic and financial, multiple- and single-purpose projects, benefits and revenues, and costs and expenditures. More detailed treatment

of these concepts may be found in several standard works used by U. S. government agencies, (42, 43, and 44), and in previously cited references.

Economic vs. Financial.—The economic concept is much broader than the financial. The economic is concerned with the alternative uses and returns from resources over time and their effect on the larger economy. A project may stimulate employment and increase factor returns, enhance, through external economies, the productivity of complementary industries, raise educational and living levels, and so forth. These external effects may occur whether the investment is made from public or private funds. The financial concept pertains to the borrowing and repaying of a certain sum of money, at a specified interest rate, which may or may not be an economic—or market-determined rate of interest. Generally, financial feasibility involves direct costs and returns only; economic feasibility concerns indirect costs and returns as well.

Multiple vs. Single Purpose.—Most water-development projects, underway and proposed in Taiwan, unlike the past, call for the construction of multi-purpose water facilities. Irrigation may be a secondary rather than a primary purpose. In case of the Ta-Pu Reservoir project, irrigation was the primary purpose and flood control and recreation were secondary. When more than one purpose is involved, the feasibility and repayability calculations are complicated by joint-cost allocations among purposes. It is generally agreed that each purpose should yield benefits at least equal to its incremental (separable) cost and that the overall project benefits should equal or exceed total costs. All joint-overhead costs are assigned to each purpose in the same proportion as separable costs (44).

There are some who argue that allocating costs by purpose is immaterial, the important consideration is that total revenues of a multi-purpose project exceed total cost (5). This principle is fully accepted within business enterprises but is somewhat difficult to apply in projects financed with public funds, in which the separate purposes (power, irrigation water, public water, flood control) are administered by different entities (public, quasi-public and private) and each is responsible for repaying its allocated costs. If one organization were responsible for financing, managing, and repaying a multi-purpose project, it could charge for services on the basis of the value of benefits received (demand) rather than on the basis of

separate costs. The crucial point would be that total revenues exceed total costs.

Benefits vs. Returns.—Although a later section is devoted to benefits, the conceptual difference between benefits and returns needs to be treated here. The concept of benefits as used herein, and in most public investment-feasibility studies, visualizes a wide sweep of economic and social gains that can be directly or indirectly attributed to an investment project. Unlike direct returns or revenues, the chief sources for the repayability of borrowed funds, benefits may be intangible as well as tangible, social as well as private, and external as well as internal. As such, however, total benefits generally are not fully identifiable or quantifiable. This deficiency saves the analyst from possible embarrassment that may arise because of double-counting and ballooned statistics. The nature of an economy is one of interdependence of sectors and industries and the growth of one may be induced by the benefits flowing from others. How much of the growth, measured by net earnings or profit is attributed to each beneficial influence is difficult to ascertain and even more difficult to assign*. Moreover, the advancement of one industry or sector may create diseconomies and losses for another.

In this report, only the tangible primary benefits will be employed for feasibility analysis purposes, for several reasons. First, the tangible primary benefits are the easiest, though difficult, of all benefits to identify and quantify, as will be illustrated later. Second, the tangible primary benefits correspond more closely to the revenue or return concept familiar to business enterprises, which recognize but do not attempt to internally capitalize the value of their investments to others. Third, the tangible primary benefits are the source for the repayment of borrowed investment funds.

The broader concept of benefits, however, has two valuable uses. One is to determine the priority of projects yielding the same rates of tangible return on the investment. The other is to determine which projects, or

* The U.S. Bureau of Reclamation attempts to assign a percentage of the increased profits of processing industries that may be attribute to the increase in agricultural production due to irrigation (42). However, the effect of increased output on transportation and storage costs and the ripple-effects in other secondary and tertiary industries are disregarded. On the other hand, the U.S. Department of Agriculture and U.S. Army Engineers, in evaluating the feasibility of water-development projects do not pursue benefits to these extremes.

portions of a project, to subsidize. Some investments, such as schools, roads, or recreational facilities, may yield high unassignable and intangible benefits warranting a public investment that is not to be wholly repaid by the users or beneficiaries. Irrigation, too, may yield subsidizable benefits.

Costs vs. Expenditures.—A conceptual problem exists on the cost side of the feasibility equation, too. Economic costs may be different and smaller or larger than expenditures. The true cost of a project is the cost of providing the same services or goods by an alternative method. In the case of irrigation in Taiwan, the economic cost of providing a given amount of water to a selected area would be the least-cost method from among the alternatives of (a) reservoirs, (b) river diversions, (c) conveyor canals from water-surplus areas, (d) ground-water pumping, (e) salt-water conversion, and (f) cloud seeding and pond catchments. The alternative-cost principle is applicable in choosing between single-purpose irrigation or multi-purpose water projects, among water sources in irrigation districts, and among irrigation methods on individual farms. Seldom, however, are such alternative costs computed each time a decision is to be made; most alternatives are eliminated beforehand for a variety of reasons. Consequently, planned expenditures of a pre-selected irrigation facility rather than the economic costs of an alternative method are used for determining the priority and feasibility of projects. Actual expenditures, which, for a number of reasons, are usually higher than planned, are the amounts scheduled for repayment and/or subsidy. For example, the Shihmen Reservoir project in Northern Taiwan is expected to cost about four times more than the original estimate and the Ta-Pu Reservoir project, the case studied in this report, cost twice as much as originally planned.

Interest, the cost of borrowing money, is usually considered as separate from and an addition to project costs. However, interest may be viewed as a return, i. e., a surplus over costs, as well. We will note later that the interest rate enters into both sides of the benefit-cost equation, and the revenue-cost surplus, if any, is stated in terms of the rate of return on the investment.

Having considered alternative concepts and disposed of those that are not relevant to our problem, further treatment is warranted for the two concepts that are important: tangible primary benefits and investment expenditures.

TANGIBLE PRIMARY BENEFITS

The benefits used in this study for the capitalization of irrigation investment expenditures are the tangible primary benefits, which can be quantified and assigned to the chief beneficiaries. Restricting the analysis to these benefits considerably simplifies the feasibility problem, other awkward problems remain, however. The major remaining problems to be considered here are: (1) quantifying and assigning of public and private benefits; (2) maximizing of benefits; and (3) averaging of private benefits.

Quantifying and Assigning of Public and Private Benefits.—The initial problem is to separate public and private tangible primary benefits. The major benefits from increased food production attributable to irrigation are distributed in a free market system through the price mechanism. Some of the benefits may accrue to producers as increased total returns; some to consumers in the form of lower prices and higher incomes; and the rest to government as taxes. In Taiwan, most of the farmers are private entrepreneurs but some are government-owned corporations. The benefits to both are considered as identical and available for repayment purposes. However, private farmers generally retain some of the extra production for their own consumption; an imputed value is assigned this quantity in calculating total benefits. Also, as was noted in the opening section, the government intervenes in some commodity markets, notably the rice market, and the market is not free to establish an equilibrium price or to distribute rice according to buyers' preferences. Producers are deprived of the full value of the rice marketed; the amount of benefits lost was calculated in an earlier chapter. Certain consumers are subsidized by the government largely at the expense of producers. What otherwise would be private benefits are transformed into immeasurable, and perhaps smaller, public benefits. This accounting problem is disposed of in the next section.

Even though increased production may lead to increased tax revenues, such revenues should not be considered as tangible public benefits for two reasons. First, taxes are accounted for in computing net private benefits, and as such are treated as other factor payments which directly or indirectly are expended for the benefit of agriculture. Second, it is assumed that the costs of providing social overhead facilities increase in proportion to the increase in the total value of production of an improved or newly irrigated area. If a net gain in social overhead were assumed, one would

have to consider the possibility, too, that a net loss in social benefits might be the consequence of increased tax payments.

Maximizing of Benefits.—The goal of maximizing primary irrigation benefits brings to the fore a number of difficult problems pertaining to prices, cropping patterns, and technological changes arising in a dynamic situation. The price problem is perhaps the most important, of which two aspects need attention. The first is the lack of free market prices for some commodities, as mentioned previously, and the second is the long-run commodity price prospects anticipated for the life of a project. These two price problems are mutually independent but interrelated. Future government price policy is an unknown, but it is assumed in this report that domestic market prices more nearly reflect the long-run price situation than do government controlled prices. The 1962 free-market-rice price in Taiwan was approaching the import-price level, which may be used as an alternative price in computing benefits for feasibility purposes. However, internal prices are used for computing benefits since they, and not external prices, more nearly reflect a nation's true comparative values. If external (import or world market) prices were used for one commodity, they ought to be used for all. Another question is whether present or future prices should be used in calculating the value of benefits continuing the life of the project. Obviously, future commodity prices affect all economic value-and repayment calculations. The long-run agricultural price prospects for Taiwan are clouded by (a) the lack of satisfactory historical and commodity prices on which to base forecasts, and (b) the persistent pressure of price inflation.

The United States Department of Agriculture has prepared long-run commodity price indices for the U. S. agencies concerned with water-development feasibility studies. Some of these long-term price projections, particularly for comparable commodities, as shown in Table 27, may be of interest for Taiwan.

It is apparent from the table that the U. S. long-run price of many commodities important in Taiwan's agriculture such as rice, sweet potatoes and peanuts, are expected to decline. On the other hand, the prices of animal products are likely to rise. There is reason to believe that similar long-run price trends can be anticipated in Taiwan.

Table 27. United States Department of Agriculture Long-Run Price Projections for U. S. Domestic Crops

Crops	Change in expected long-run prices relative to 1955 prices (percent)
Rice	−28
Wheat	−21
Cotton	−22
Soybeans	+ 5
Peanuts	−34
Sugarcane	+14
Sugar beets	+ 8
Oranges	−15
Potatoes	− 2
Sweet potatoes	−33
Hogs	+13
Cattle	+17
Chickens	+ 7
Eggs	+ 8
Tobacco, flu-cured	−17

Source: United States Department of Agriculture, *Agricultural Price and Cost Projections* for use in making Benefit and Cost Analyses of Land and Water Resource Projects; Agricultural Research Service and Agricultural Marketing Service, Washington, D. C., June 1956.

Complicating the commodity price-forecasting problem in Taiwan is the future rate of price inflation. Anticipated price inflation, especially of benefits, can be corrected for in feasibility studies by means of an inflated discount rate of interest. Price inflation is more difficult to neutralize, however, when considering repayment potentials, particularly if the interest rate charged borrowers is subjectively determined by the lender rather than objectively in the market place.

In any discussion of maximizing benefits in the long-run, one needs to consider the prospect of changing crop-and land-use patterns. Basically, crop and land-use patterns are determined by two forces: (1) the adaptation of known economic crops and livestock to the environment, and (2) the human instinct of seeking out nutritionally balanced, energy-producing foods, and a more varied diet with rising incomes. The environment can be modified in many ways, of which irrigation is but one.

Rice is considered the most important single staple food in Taiwan, and double-paddy rice, which is fully dependent on irrigation, as the

ultimate in intensive land use, especially when other crops are grown between rice harvests. Rice accounted for 45 percent of total value of all agricultural production in 1960, and 48 percent of all crop acreage. Irrigation project planners aim for double-paddy rice, and most farmers shift to double-paddy as soon as an adequate water supply is assured. On the margin, however, irrigated paddy land is being shifted to more valuable agricultural uses (cf. page 36).

Whether measured in terms of nutrients or money value, other crop-livestock combinations may yield higher benefits per hectare, as is illustrated in Table 28. If Japan's food consumption experience is accepted as a future reality for Taiwan, a substantial shift in Taiwan's land-use patterns will occur. Rice and sweet potatoes will give way to more livestock, milk, vegetable, and fruit production. Per capita consumption of selected foods in Japan and Taiwan in 1958 is shown in Table 29.

Table 28. Farm Income With and Without Dairy Enterprises per Hectare, 1960

	Gross farm income			Farm expenses NT$	Net farm income NT$
	Crop NT$	Livestock NT$	Sub-total NT$		
With dairy	6,887	9,621	16,508	14,279	2,229
Without dairy	6,769	2,917	9,686	9,657	29

Source: S. C. Hsieh, Y. T. Wang and Y. L. Tong, "A Comparative Study on Farms With and Without Dairy Enterprise in Taiwan", *Journal of the Agricultural Association of China*, June 1961 (in Chinese).

Land-use tranformation will be from the less to the more profitable crops and generally from cereals to meats, fruits and vegetables. The U. S. Bureau of Reclamation reports a decided shift over the years in the types of crops produced in its irrigation projects. Vegetables, for example, increased from 11.7 percent of total crop value in 1920 to 22.2 percent in 1960. Fruit and nut crops increased from 11.4 percent in 1920 to 14.7 percent in 1960 (45). The long-run trend in prices, shown in Table 27, reflects in large measure which agricultural products will be favored by stronger consumer demand.

The shift to higher-value crops on irrigation projects is recognized by Eckstein (2) as a factor that needs to be reckoned with in computing benefits. He recommends that positive compensating factor be applied to

benefits to allow for rising long-run changes and benefits. An attempt is made in the Ta-Pu case study to allow for an expected long-run change in land-use patterns. The longer the economic life and repayment period of a project, the larger the influence on benefits of anticipated value changes due to shifts in cropping patterns.

Table 29. Annual Per Capita Food Consumption in Japan and Taiwan, 1958

Unit: kg.

	Taiwan	Japan
Rice	131.7	112.8
Wheat	20.2	24.1
Barley	—	13.3
Sweet potato	69.4	23.9
Soybean	15.0	5.1
Vegetable	60.6	72.5
Fruits	20.9	21.1
Meat	18.6	3.1
Egg	1.7	3.9
Fish	20.7	21.8
Milk	1.0	17.8
Sugar	9.4	13.8
Oil	4.3	3.4

Sources: Taiwan: *Taiwan Food Balance Sheet*, 1960, Joint Commission on Rural Reconstruction. Japan: T. H. Lee, "Current Agricultural Problems and the Agricultural Basic Law in Japan", unpublished report, Joint Commission on Rural Reconstruction, December 1961.

Technological changes in the application and use of water may bring about increased benefits, too. For example, where rotational irrigation has been tried (in contrast to constant flooding) rice yields have been increased by as much as 15 percent. Experiments with sprinkler irrigation of sugar in Taiwan resulted in 0.742 tons more than was obtained from regularly irrigated plots, (46) in addition to saving a vast quantity of water. As water becomes more valuable, improved technological methods of water distribution will become necessary to obtain higher yields from water inputs. If farmers paid for water on the basis of the amount used, which would necessitate a simple but effective measuring device, they would be more economical in its use and more calculating in selecting profitable crops. If farmers bid for water, the bid price would more nearly reflect the marginal value of water to each user, and land-use changes would be more frequent and obvious.

Averaging of Benefits.—Most benefit-cost studies base the value of benefits on current market prices and on actual or anticipated average yields. This method suffers from the biases of arithmetical averaging of yields; few farmers produce average yields. If skewed yields exist, the arithmetic average will be skewed, too. It may be argued that this is a minor difficulty compared to the other more serious problems affecting benefits. Nevertheless, when benefits are computed for a long-term, a serious bias may arise in computing present values if the average continuously over—or understates a true or geometric mean.

The water-pricing policy, as mentioned above, assumes that all farmers experience the same average yields, costs and net returns. This policy poses no major problem for computing economic feasibility of a project; its chief impact, as will be noted later, falls on the repaying farmers receiving less than the average benefits or experiencing higher than average costs.

INVESTMENT EXPENDITURES

Most irrigation investments are composed of three types of expenditures: (1) planning, (2) project, and (3) preservation. The major questions of interest here, are: (1) which of the investment outlays should be capitalized in determining benefit-cost ratios? (2) which should be repaid? and (3) by whom?

If an irrigation project, whether single-or multi-purpose, were constructed and operated by a private or a public enterprise, without subsidy, these questions would have little significance. Consumers would be expected to repay all outlays. The questions are pertinent for Taiwan because most irrigation construction outlays are supplied from public funds and operating expenditures are met from private (farmers) sources. Farmers, as users of water, may be required to repay a part or all of the public outlays.

Water resources planning in Taiwan is considered a Provincial function, and all project investigating and planning costs are borne by the government. These public expenditures are not capitalized in computing benefit-cost ratios, and they are not repaid directly from project revenues.

Project investment expenditures, largely construction costs, are provided by government on a loan and/or grant basis. Upon completion, the irriga-

tion system is turned over to an Irrigation Association, which is responsible for operating, improving and extending the system and repaying the loan portion, all under government supervision. Preservation costs (maintenance, repair and depreciation) are collected from farmer members, on a per hectare basis, as ordinary water fee. The fee averaged NT$ 412 per hectare in fiscal 1960. Special water fees are collected to repay project investments and special improvement loans.

Capitalization of a project's investment cost encounters two problems. Should, for example, the preservation, improvement and extension costs, met from private (farmers) funds, be capitalized with the project costs financed by government? In the first instance, the costs are continuous and fairly regular whereas project costs terminate when the project is completed. In this report, the two outlays are handled separately. The regular, ordinary outlays are considered as associated costs, like farming costs, and are subtracted from annual gross benefits in arriving at net benefits and present values.

The second problem concerns the salvage or residual value of an irrigation facility at some future date. The salvage value of a permanent facility such as a reservoir is a credit on the cost side of the benefit-cost formula. A future salvage date falls short of the date when the installation has no economic life remaining. It is an arbitrary date selected for discounting purposes. Most water-project feasibility studies in the United States are based on a 50-year discounting period even though the economic life of a project may well be 100 years or more. Beyond 50 years the present value of an annuity, at a given discount rate, changes very little from year to year. (An annuity whose present value is 1, discounted at 12 percent per annum, has a value of 0.120417 for 50 years and 0.120143 for 100 years.) The measurement and assignability of salvage value are more accurate for single-purpose than for multi-purpose projects, and for those projects in which the economic life of the various components is more nearly the same than for those projects with wide ranges in the life span of components. The discounting period is usually related to the most durable and expensive structure. Components with a shorter life than the discounting period are considered to be replaced from current benefits, which reduces the benefits available for discounting to present values. The

salvage value covers all facilities enduring beyond the discounting period, even those replaced since their original installation.

BENEFIT-COST ANALYSIS

After clearing up numerous concepts and propositions that have a bearing on the economic feasibility of a project, we arrive at the crucial juncture of prescribing formulas for the determination of economic feasibility. However, before presenting formulas, we must dispose of an ingredient as vital to feasibility studies as the value components of the formulas, i. e., the discount rate of interest.

Discount Rate of Interest.—The rate of interest is the product chiefly of the time preference for and the productivity of capital. A high time preference for immediate consumption of goods is associated with a high rate of interest. High consumption may be due to uncertainty of the future, consumers striving to narrow the gap between the present level and their standard of living, or for other reasons that favor the present over the future. A high rate of productivity, or a high marginal efficiency of capital, produces a high interest rate. As capital accumulates, the interest rate falls unless the marginal efficiency of capital increases faster or the time preference for immediate consumption rises.

A discount rate of interest is a recognition of the basic economic fact that some future value (x) has a lower present value (x-n). The amount of the difference can be converted into an annual discount rate of interest. In classical economic theory, the demand for and a supply of capital established the level of discount rates; each sub-market had a separate rate. Modern economic theory recognizes competitive imperfections in the capital market, particularly on the supply side, which is often used by government as justification for intervention. As supplier, regulator, and borrower of funds, government actions often add to the imperfections. If a government's position in the money market is powerful, it may manipulate interest rates within a substantial range for policy-fulfilling purposes. Subjective criteria may prevail over economic criteria in rate setting. This characterization represented the interest-rate situation in Taiwan in early 1962.

Inasmuch as most large-scale irrigation investments are made with public funds, the question of the appropriate discount rate has been subject

to considerable debate among economists. The common practice in the United States is to use the Federal Government's long-term bond rate as the discount rate. It is a market-determined rate and bond monies supply most of the public-investment funds. In recent years, this rate has oscillated around 4 percent. Eckstein argues that on the basis of the opportunity-cost principle, the real cost is more nearly 6 percent, which is the probable earning power of the monies (taxed away) if they were left in the hands of the public (2). Hirschleifer, DeHaven, and Milliman use the same principle to argue that the real cost is what a private investor (public utility firm) would require as a rate of return, not only for a reasonable profit but also to pay taxes, which a government enterprise escapes but ought to pay. The latter authors arrived at a 10–12 percent rate as being the real opportunity cost of such investments (5). As an alternative, they suggested that if government continues to finance such projects financing should be with revenue rather than general obligation bonds, which would subject the economic feasibility of each project to the scrutiny of the money markets. The present writers favor revenue-bond financing, in principle.

These theoretical and methodological arguments about the real discount rate of interest have much practical significance. A low rate tends to favor a large investment or a long-term pay-off of a given investment. A high rate reflecting a higher time preference, a higher marginal efficiency of investment, and an inadequate supply of capital to meet all demands, tends to restrict the investment to a smaller amount and encourages a rapid repayment of a given amount of investment. A high rate tends to favor, which it should, high-depreciation cost projects, such as groundwater pumping, over low-depreciation projects such as reservoirs.

The discount rate need not be the same interest rate as that charged borrowers for repayment purposes. However, in a free market situation, the two rates would not diverge widely. The discount rate would reflect the average or median rate of return on all investments of a given quality. Some investors would earn more and some less. A repayment rate of interest which is less than the internal rate of return would provide investor-borrowers with unearned gains and encourage more borrowings until a new equilibrium level between the repayment rate and internal rate of interest were achieved. A higher repayment rate would force faster repayments (forced savings) and discourage further borrowings on these terms.

The lack of an appropriate discount rate of interest is a more vexing problem for Taiwan than for the United States, for the many reasons previously enumerated. The absence of a long-term, market-determined rate of interest is perhaps the major reason, which can be traced to: (1) the strong demand for short-term funds, (2) excessive consumption; and (3) the lack of appropriate institutional arrangements to accumulate funds for long-term lending. If the market were free to determine all prices, including interest rates, most long-term investments, especially those in the social overhead category, would be postponed until the long-term rates were sufficiently above short-term rates so as to attract the needed long-term capital. This sequence of events is not permitted to evolve naturally in Free China, for a variety of reasons. Attempts are being made to meet both short- and long-term capital needs simultaneously and long-term funds are often supplied at rates below short-term rates. The forced draft of funds for long-term purposes starves the short-term market of funds and helps keep short-term rates high. The depressed long-term rates encourage projects that in a market-determined situation would be postponed and that are inefficient in the use of funds.

Raising the long-term rate to an arbitrary 12 percent per annum, as explained in an earlier section, has had the effect of delaying long-term projects and making more funds available for short-term lending. Moreover, it has helped to reduce short-term rates.

The 12 percent rate, though arbitrary, provides a parameter for the determination and measurement of other economic values. In this report and in the study of the Ta-Pu project, the 12 percent rate is the rate used for discounting of benefits and costs. Although this rate is below the present opportunity cost for such funds, any economic losses can be partly offset if the projects yielding the highest internal rate of return receive top priority for construction. Also, the relatively low discount rate produces higher present benefits than would a higher rate. Hence, a lower-than-market rate helps compensate for the increasing future benefits from irrigation that are normally disregarded in benefit-cost analyses.

Benefit-cost Formulas.—The traditional benefit-cost formula operates on the basis of the ratio expression of $\frac{B}{C}$. B represents average annual net benefits and C average annual costs, with interest and depreciation

included in costs and excluded from net benefits. It is proposed, however, that the concepts and formulas recommended by Hirschleifer, DeHaven and Milliman, based on the principle of B–C, are the more relevant. Two fundamental formulas are employed herein for determining economic feasibility of a project. The first assumes discounting for the full period of economic effectiveness of the investment. The second assumes discounting for a shorter period, with a salvage value remaining after the discounting period.

(1) Discounting for full life of investment:

$$V_0 = -C_0 + \frac{S_1}{1+i} + \frac{S_2}{(1+i)^2} + \frac{S_3}{(1+i)^3} \cdots + \frac{Sn}{(1+i)^n}$$

(2) Discounting for less than full life of investment:

$$V_0 = -C_0 + \frac{S_1}{1+i} + \frac{S_2}{(1+i)^2} + \frac{S_3}{(1+i)^3} \cdots + \frac{St=(bt+sv-ct)}{(1+i)^t}$$

V_0 represents present value or present net worth, which may be expressed in money units or as a percentage of C_0. A positive V_0 suggests that the project is economically worthwhile. C_0 is the initial investment, usually a large lump sum. S_1, S_2, S_3 represent the differences between benefits and related costs for the time periods (annual, in our illustrations) 1, 2 and 3, etc. All expenses incurred in the creation of benefits during each time period, even the community expenses of maintaining and repairing an irrigation system, are treated as negative benefits. Interest and depreciation are implicitly allowed for in the formula. The denominators $1+i$, $(1+i)^2$, etc. are the discounting terms with i as the discount rate of interest (assumed to be 12 percent in our study).

In formula (1) Sn represents the last year in which the investment has any effect. In formula (2), $St=\frac{(bt+sv-ct)}{(1+i)^t}$ represents the value of S in some selected time period, t, which may be any period short of the full life of the investment. bt represents gross benefits, sv the remaining salvage (economic) value of the investment in period t, and ct the costs or negative benefits in time period t. Formula (2) is merely an adaptation of formula (1) but is useful in at least three situations. First, it provides a semblance of realism in determining present values of extremely durable, long-term projects, which may last for 100 years or more. Second, it

enables individual purposes of multi-purpose projects to be discounted separately and allows recognition of the remaining value of the facilities serving several purposes. Third, it gives proper weighting to the present values of projects with different life spans, which are being compared for priority purposes.

Priority of Projects

One of the major purposes of all benefit-cost analyses, and generally disregarded by economic planners, is to use the results in selecting or determining the priority of projects. The idea is to select the projects, assuming a given investment budget, that will maximize returns (return the investment quicker for re-investment elsewhere). This is an important principle for economically-developing countries to follow but one that is easily negated by inexperience or political reasoning (1a). The economically less-favorable projects need not be abandoned but merely postponed until (a) the more favorable projects are completed, (b) the market interest rate falls, or (c) the benefit-cost ratios of postponed projects improve (higher benefits and/or lower costs). To rank projects ordinally by rates of return suggests that the decision-making authority has an inventory of planned projects from which to choose, with reliable benefit-cost data for each.

MAXIMIZING RATE OF RETURN

The rate of return, expressed as a percentage of capital investment, remains the best single measure for choice-making. Projects with the same positive present values may exhibit different rates of return; the higher should be preferred. However, as will be noted later, projects with high tangible secondary benefits and intangible benefits may be chosen for their social rather than direct economic benefits (34a).

Two formulas may be employed in determining rates of return and priority of projects. Formula (3) functions on the principle of a fixed-current investment budget and suggests that the projects with the successively highest rates of return be adopted until the budget is exhausted.

(3) Fixed-budget rationing:

$\frac{V_1}{C_0}$ where

$$V_1 = S_1 + \frac{S_2}{1+i} + \cdots\cdots + \frac{Sn}{(1+i)^{n-1}}$$

V_1 is the value of all S's (net benefits) discounted from time n back to time 1. C_0 is the fund invested in the initial period, V_1/C_0 yields a rate of return, which diminishes as the highest yielding project is budgeted.

The second formula, formula (4), determines the rate of return by approximating the discount rate of interest that will reduce the S's (net benefits) minus the initial investment fund C_0 to 0.

(4) Internal rate of return:

$V_0 = 0$ where

$$0 = -C_0 + \frac{S_1}{1+r} + \frac{S_2}{(1+r)^2} + \cdots\cdots + \frac{Sn}{(1+r)^n}$$

r is the discount rate (internal rate of return) that reduces the S's $-C_0$ to 0, and can only be determined by trial-and-error. Each project has some discount rate which will reduce benefits minus costs to zero. All projects with discount rates that are greater than the appropriate market rate of interest (or some arbitrary rate) are eligible for present construction. This method has several advantages: First, it minimizes the need for a uniform accurate, long-term discount rate, which is an arbitrary rate in Taiwan as it is in many other lesser-developed countries. Second, it enables an analyst to test the rates of return of the several purposes of a multi-purpose project independently of each other and in comparison to alternative methods of accomplishing each of the same purposes. Third, it provides the financial community with an understandable unit of measure for comparing investment performances among and between public and private sectors, agriculture and industry, domestic and foreign trade.

INVENTORY OF INVESTMENT OPPORTUNITIES

As was observed earlier, any concept of priority implies an inventory of processed, prospective projects. The concept is as applicable to private as to public investments, but we are limiting our concern to the latter. Keeping the private-public sectors separate becomes difficult in situations, such as irrigation, in which public funds are used to generate private benefits and in the converse situations where private funds (taxes, lotteries, bonds,

loans) are used for financing public benefits. We adhere to the principle that if benefits can be identified, quantified and assigned, the recipient beneficiaries ought to repay the investment on the basis of benefits received, whether the funds or benefits are public or private.

The priority principle encounters other problems of practical application. For example, in the public water-resource development area there is no one single agency in Taiwan that has the authority to assign priorities. The Water Resources Planning Commission (WRPC), an agency of the Central Government's Ministry of Economic Affairs, is concerned mainly with multi-purpose water projects, or water-basin planning. The Provincial Water Conservancy Bureau (PWCB) assumes jurisdiction of the irrigation facilities of completed multi-purpose projects and in initiating single-purpose irrigation projects. The Irrigation Associations (IA's) quasi-public bodies, may initiate limited irrigation investments, too. No one agency attempts to assign water-project priorities, especially on a basis of economic returns.

If priorities are applicable among irrigation projects, they are valid, too, between irrigation projects and other agricultural investments that could be undertaken to increase the value of agricultural output. These alternative agricultural investments are many. They could range from an intensive promotion program to induce wider and deeper application of known techniques, to an investment in improved marketing facilities, to a longer-term investment in basic research (47). No economically rational system has been devised to allocate public funds among alternative uses in a mixed public-private economy. The statement applies as equally to the United States as to Free China. The private-market solution, in spite of its imperfections, generally produces a more rational and balanced solution than does a public-body decision.

PUBLIC ASSISTANCE TO AGRICULTURE

In the Free World (essentially the free-enterprise version), a strong body of opinion insists that agriculture needs governmental assistance, beyond the traditional academic, extension and research, if farmers are (1) to produce the needed foodstuffs and (2) to maintain parity income with participants in industry. These proposals are too complex to be debated in this report. However, they have a bearing on agricultural policy-making

in Taiwan and on irrigation investments. Two aspects are highlighted here: indirect and direct subsidies.

An investment project that is selected because of its high indirect and intangible benefits relative to its direct tangible benefits may be no more than a vehicle for transferring incomes and wealth from one group to another and in this sense an indirect subsidy to certain beneficiaries. When intangible, indirect benefits are given paramount importance, choice-making is adrift without an objective standard for an anchor. Other investments, private and public may make similar beneficial claims that are difficult to contest rationally. Without question, irrigation has a great impact on agricultural output, which in turn influences the growth and development of a variety of secondary and tertiary industries. However, a similar amount of investment in electrical power or in a metal industry may have a greater multiplier effect on employment and incomes in the overall economy. Agricultural investments should measure up to the same standards as those in other sectors. This assumes, of course, that free market prices prevail in all sectors.

It is argued in Taiwan, as elsewhere, that because irrigation water (1) is indispensable to certain agricultural areas and crops and (2) is usually provided as a social overhead, that it ought to be wholly or partly subsidized by means of public grants and/or favored interest rates. Public policy in Taiwan, since Japanese days, has offered both heavy grants and favorable interest rates especially for the construction of large-scale irrigation projects.

Subsidies of this nature are more easily justified if used as an initial inducement to change cultural practices and land-use patterns than if used to make more profitable an already acceptable and profitable practice or land-use. The policy of continued subsidization of irrigation in Taiwan needs to be re-evaluated. On the side favoring continued subsidization are these points. First, some lands, public and private, require such a high reclamation investment that the cost, let alone an added amount for interest, could not be repaid from the increased output in a reasonable period of time. Obviously, such investments are the ones most eligible for postponement. Second, subsidization of one group and not another creates problems of equality; some farmers pay less for water (receive or have

received greater subsidy benefits) than do others. (This problem of different costs is well illustrated later in the study of the Chunan Irrigation Association area in which the Ta-Pu irrigation project is located.) The problem of equality is a relative one. Even in a free market situation, costs and benefits are not always allocated on an equalitarian basis. Inequality is harder to rationalize and to explain to farmers, however, when a public body controls the resource allocation and pricing system. Third, it appears that rice farmers may be paying more than their fair share of taxes in the form of the rice-price differential on the rice (about 30 percent) preempted by the government. An irrigation subsidy partly corrects for this type of over-taxation or income preemption.

On the side against continued subsidization, three points seem most relevant. First, if benefits exceed costs, and the benefits can be traced to individual farming units, the recipient should pay for the benefits received. Otherwise, some other tax-paying group is providing the benefits at its expense. Second, irrigation is well established and the benefits are well known, no social inducements are needed to encourage farmers to use water in farming. The incremental income benefits from irrigation, as revealed in annual income data and land value increases after irrigation, suggest that direct benefits from irrigation are substantial. Third, farm economic studies show that many farmers have a greater ability to repay irrigation investments than has been required of them in the past. There is a point, of course, at which the costs for water could be too high. What is a reasonable water charge is the chief topic of the next section.

Repayability of Investment

Favorable economic feasibility of irrigation projects is predicated on the assumption that all costs, including interest and depreciation, can be repaid from benefits. At the outset, we should review in more detail the basic differences between the two concepts of economic feasibility and financial repayability.

ECONOMIC FEASIBILITY AND REPAYABILITY

The differences between these two concepts may be observed in the four components of an investments: (1) amount of the investment; (2) term of the loan; (3) the interest rate, and (4) the amortization repayment

schedule. The amount of the investments, to be repaid, as was noted earlier, may be less than the cost of a project by the amount of a subsidy grant. The term of the loan may be shorter or longer than the discounting period used to determine feasibility. Generally, it is much shorter. A short repayment period is one method of reducing the interest rate risk, particularly where inflation is real or threatens, and is an effective method of forced savings and a quick return of capital. On the other hand, as will be observed in the Ta-Pu study, a short repayment schedule may create serious economic pressures for farmers and collection and financial problems for Irrigation Associations.

The interest rate charged borrowers may be less or more than that used for discounting. It is unlikely to be more especially if the discount rate approximates the market rate. However, it may be higher if water is offered under monopoly market conditions and the seller (or lender) may wish to extract extra revenues from the water users, which can be used for transfer payments, social overhead, or reinvestment in agriculture, or retained as profit, if a private firm. Or, the rate may be higher to pay the administrative costs of operating the irrigation facility, if special fees are not collected for this purpose. It will be demonstrated later that some farmers are willing to pay a water fee that returns more than 12 percent on the investment in order to obtain irrigation water. If the interest rate charged farmers for repayment of irrigation facilities is different than the discount rate, it is more likely to be lower than higher*.

A low interest rate can be used as a subsidy to induce the undertaking of certain socially desirable projects such as irrigation, rural communications and power, even if the primary benefits accrue to private firms.

The amortization schedule for the repayment of principal and interest may differ from the anticipated receipt of benefits. Repayment may be at a constant amount per payment period (usually every 6 months for irriga-

* In the United States, for example, the U. S. Bureau of Reclamation does not charge interest on the irrigation portion of the investment in a multi-purpose water project. The interest charge is borne by the power segment of the investment. The economic rationale for this policy may be found in three reasons. First, the consumer demand for power is stronger than the consumer demand for irrigation-produced crops. Second, irrigation in most projects of this kind is a joint-product and of lesser importance to the total investment than the other purposes. Third, the water may be destined for marginal lands on which the net returns to farmers may be low, and their desire for the project indifferent. The Bureau of Reclamation considers repayment of principal as an adequate burden; at least repayment defaults will not result in increasing the amount due which would occur if a compounding interest rate were charged, too (43).

tion projects in Taiwan), or graduated, with the repayment amounts increasing or decreasing over time. Interest may be paid separately from the principal, which will mean decreasing interest payments as the amount outstanding diminishes. Or, as is the usual method, one payment is used to cover both principal and interest, with interest deducted first and the balance applied to the principal. Repayment may be postponed for a few payment periods, except perhaps for interest, to allow farmers to make necessary capital expenditures and adjustments in adapting their operations to irrigation.

All of these variations are institutional devices for accomplishing the financial repayment of some predetermined amount. The terms may vary from complete subsidy to no subsidy and to repayment charges that make the application and use of irrigation water uneconomical. Terms could be so structured that the amount paid for water would be equivalent to economic rent—just the amount necessary to pay all costs for the duration of the economic life of the fixed investment, including a market rate of return on the investment and depreciation. Generally, a payment amount approximating economic rent would be much less than now required of farmers who are expected to repay in 20 years or less an investment having an economic life of from 50 to 100 years or more. If the water facility were owned by the government or a public-utility firm, a long-run cost-pricing method would more likely prevail, as it does in the Taiwan power industry. Costs, however, are not the sole determinant of water prices. The other determinant is the farmers' demand for water, their marginal value of water, which is a demand derived from the value of the products produced. The crucial question remains, how much can farmers pay for water?

FARMERS' PRICE FOR IRRIGATION WATER

An attempt is made to answer the question of how much farmers can pay for water both theoretically and empirically. If the water supplier is interested in maximizing profits he will attempt to supply the amount of water at which the marginal cost for his water will equal the marginal revenue from water sales. If he is more concerned with supplying the maximum of water at the lowest price, which presumably is the attitude of public bodies, output will be extended to where average costs and average revenues are equal, thus eliminating profits. Normally, the unit price

for water will settle at or between the average cost (supply price) and the average product value (demand price). Generally, the price at this point will be lower than the price at the point of profit maximization (see Chart 5). In the short run, the price could extend beyond either of these two limits. In the long-run, the price would have to stay within these limits. If above the average product value, the farmer would be losing money and would discontinue buying water if he were free to do so. He would be losing money in the sense that he could (a) provide the water less expensively by some other method; private pumping perhaps, (b) shift to a more profitable cropping pattern not requiring water, or (c) invest the money spent for irrigation water in some machine or farming improvement that would yield him a greater return in the long run than his investment in water. If in the long run, the unit price were below the average supply price, deterioration of the water system would eventually result in the discontinuance of water service, unless the system were subsidized, which a government body can do more discretely than can a private firm.

The upper and lower price limits do not remain static over time. The average costs of providing water from nonsaleable irrigation projects endowed with heavy initial investments are likely to remain more stable over time than are the average product values, which are likely to rise perceptibly with changing price levels, incomes, and land-use patterns. The average costs of short-term projects, such as deep-well pumping, are more likely to rise from one replacement period to the next, largely because of increasing costs.

Most irrigation projects are faced with a major built-in pricing weakness that was touched upon earlier. All economic feasibility studies treat benefited farmers as a group and the pertinent cost-value concepts are average costs and average product values for all farmers. No allowance, except in the averages, is made for differences in the cost of water applied or in the value of water to each hectare or farmer. Some qualifications of this statement are in order. The irrigation law in Taiwan states that (1) farmers for whom a special project is built are to pay all of the costs in the form of special water fees, which other farmers in the same irrigation association do not pay; and (2) within a project special direct costs, such as pumping, or canal lining, are to be charged to the direct benefici-

aries only. The economic burden for farmers within a project area is likely to be disproportionate in that the extra benefits from irrigation are no more and are likely less for those farmers bearing such special costs. The obstacles to charging each farmer for water on a marginal product-value basis are numerous. The lack of an adequate measuring device for small quantities of open-ditch water, the large number of small plots cultivated by the average farmer, and the lack of free-choice for land-locked farmers of buying or not buying water and in electing their cropping patterns, are perhaps the major obstacles to such ideal pricing.

As a consequence, some farmers pay more for water and others less than they would pay in a free-choice market. Hence, the financial burden is greater for some than for others. In general, the greatest burden is on those farming and living off of small acreages; as much of their input is needed to supply their own living needs.

Several empirical examples are available to indicate what farmers pay for irrigation water and what they are willing to pay.

The statistics in Table 23 showed what farmers were paying for water in 1960 on a per hectare and per household basis in each of the 26 Irrigation Associations.

The average costs for providing water varied substantially among Irrigation Associations. These differences reflect many cost variations such as, type, age, and original cost of the irrigation facilities, land-use patterns, management policies, subsidies, and economic adequacy of the charges. The Association statistics do not reveal how much farmers could pay or would be willing to pay for water. This information was acquired from an analysis of seven private-water pumping and sales operations in Southern Taiwan, as shown in Tables 30 and 31. The data were gathered in early 1962.

The first four records were obtained in the Kiangsan area, a water shortage area, north of Kaohsiung. The water was pumped from deep wells and discharged from small pipes, and was the only controlled irrigation water to the buyers. The other three cases were obtained from the Pingtung area, east of Kaohsiung, where the ground-water level was higher and discharges were from larger pipes. The Pingtung wells were the only

Table 30. Costs and Returns of Private-Water Pumping in the Southern Area of Taiwan, 1962

Location	Well No.	Total capital[1] outlay (1) NT$	Annual pumping costs				Total return (6) NT$	Net return (7) NT$	Net profit (8) NT$	Rate of return on capital[3] (7/1) (percent)	Ratio of profit[4] (8/1) (percent)
			Variable costs (2) NT$	Fixed costs (3) NT$	Interest[2] on capital (4) NT$	Sub-total (5) NT$					
Kiangsan	1	10,900	6,675	1,310	1,962	9,947	12,122	4,137	2,175	37.95	19.95
〃	2	13,468	6,600	1,298	2,423	10,321	12,204	4,306	1,883	31.97	13.98
〃	3	15,050	6,897	1,720	2,709	11,326	11,940	3,323	614	22.08	4.07
〃	4	9,600	6,720	1,163	1,728	9,611	10,400	2,517	789	26.21	8.22
Pingtung	5	28,600	7,190	1,653	5,148	13,991	25,350	16,507	11,359	57.71	39.72
〃	6	27,100	9,625	1,639	4,878	16,142	26,340	15,076	10,198	55.63	37.63
〃	7	24,500	8,995	975	4,410	14,380	23,940	13,970	9,560	57.02	39.02
Ave. (1-4)		12,254	6,723	1,373	2,206	10,302	11,667	3,571	1,365	29.14	11.39
Ave. (5-7)		26,733	8,603	1,422	4,815	14,840	25,210	15,186	10,370	56.81	38.73

(1) Original capital outlay converted to 1962 prices.

(2) Assumed to be 18 percent per annum.

(3) Includes return on management.

(4) Excludes 18 percent per annum interest charge on capital.

Source: Field study conducted by Rural Economics Division, JCRR, April 1962.

Table 31. Average Pumping Costs and Returns per Outlet Size per Hour, in the Southern Area of Taiwan, 1962

Well No.	Pump outlet size (inches)	Total pumping hours per year (hours)	Water price per hour (NT$)	Average pumping cost per hour (NT$)	Water price per 1″ outlet size per hour (NT$)	Ave. pumping cost per 1″ of outlet size per hour (NT$)	Water price per ha. of double paddy per year (NT$)	Hectares irrigated per well (ha.)
1	3.0	1,316	9.21	7.56	3.07	2.52	6,300	1.9
2	2.5	1,194	10.21	8.64	4.08	3.46	6,600	1.5
3	3.0	1,540	7.75	7.35	2.58	2.45	6,600	1.0
4	2.0	1,403	7.41	6.85	3.70	3.43	—	1.0
5	4.0	1,743	14.54	8.02	3.64	2.01	—	3.0
6	5.0	2,590	11.69	6.23	2.34	1.25	3,835	4.0
7	6.0	1,854	12.91	7.75	2.15	1.29	3,190	6.0
Average (1-4)		1,363	8.56	7.56	3.25	2.86		
(5-7)		2,062	16.29	7.19	2.44	1.43		

Source: Field study conducted by Rural Economics Division, JCRR, April 1962, and Table 30.

source of water for the first crop of rice and a supplementary source for the second crop. Only five of the seven cases used the private-well water for rice, the other two cases purchased the water for other crops.

In Table 31 we may note that farmers in the Kiangsan area were paying as much as NT$ 6,600 for water per hectare per year (The water buyers from pump number 1 paid the highest water price for the first crop, NT$ 4,180 per crop hectare. The fee for the second crop was lower because water was available for other sources). In the Pingtung area farmers were paying between NT$ 3,000 and 4,000 for water per hectare per year. In both areas, the rates of collections were high.

It may be of interest to note that the private pumpers in the Pingtung area, obtaining a lower price than the Kiangsan pumpers, earned a substantially higher rate of return (including a return for management) than did the Kiangsan pumpers. (Table 30.)

Comparing costs, returns and profits on a per hectare basis was unsatisfactory for two reasons. First, the method of charging for water differed. For rice it was usually stated in terms of Taiwan catties per hectare; for other crops the water fee was so much an hour. Second, the quantities supplied varied depending on the size of outlet and the number of pumping hours. In order to make use of the data for all cases and to make the data as comparable as possible, we have stated costs and revenues in terms of per outlet size per hour (Table 31). When compared on this basis the profit spread between the two areas was narrower, although the profit margin was still much greater (area P. in Chart 5) for the Pingtung area-pumpers than for those in Kiangsan area (area K)*

An attempt is made in Chart 5 to depict the average cost-revenue situation in Kiangsan with area K and the similar situation in Pingtung with area P. The individual cases would be arrayed around the points shown.

* The theoretical aspects of irrigation water-pricing, as revealed by the private pumping statistics, may be of interest to some readers.

The basic demand curve (average product value) for water was assumed to be the same for the two areas and for farmers producing the same crops (we assumed the main crop to be rice). In general, the demand for water was inelastic and the lower the price the more inelastic the demand(as portrayed by area P in Chart 5). The higher the price the more resistance from buyers; buyers became more economical in the use of water, and they sought and used other

sources of supply. In Southern Taiwan, the private water buyers agitated strongly for reservoirs and cheaper water from Irrigation Associations. In spite of his monopoly position, the private pumper was faced with the loss of his market if his price was too high. In Kiangsan, cheaper alternate water sources were not readily available (particularly for the first crop). In the Pingtung area, water was more readily available and if the price from private pumpers became too high, farmers might drill their own wells.

The price of privately-pumped water was not as low as it might go because of the Provincial Law which prohibited competitive commercial pumpers from sinking wells without a permit. The existing pumpers could use their prior interest as a powerful argument to prevent the granting of other commercial well permits in their supply areas. As long as they could maintain this power, their profits remained larger than they would be if there were a greater number of alternative sources of water.

Fundamentally, however, the differences in price between areas K and P were due more to production cost differences than to demand and demand alternatives. It is quite apparent from the data (as indicated, too, by the larger discharge outlets that the costs of pumping were much lower in the Pingtung than in the Kiangsan area. Even with a lower price, the Pingtung pumpers were making larger profits. The average cost curve of the Kiangsan pumpers was much more U-shape because of their high fixed-capital costs and lower volume, whereas the cost curve in Pingtung was shallower for the opposite reasons. Pumping volumes could fluctu ate more in area P without affecting average costs greatly; not so in area K.

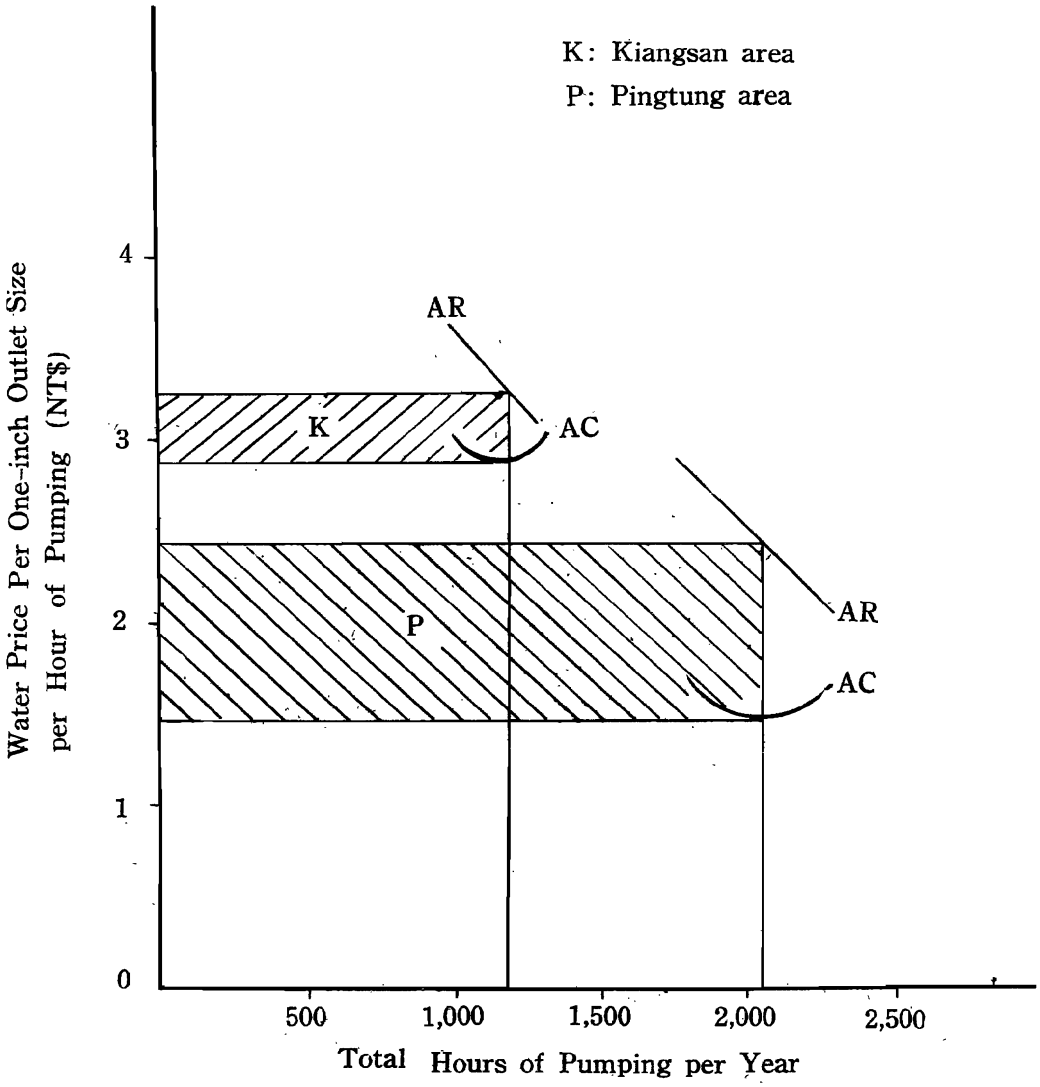
It was assumed that in both areas that each pumper attempted to maximize profits by pumping to the point where his marginal revenue and cost were equal. Private pumpers might not have been aware of their marginal costs and returns, but an equilibrium position tended to be achieved through the bilateral price—amount-bargaining process between the single seller (who was influenced by the prices charged by other pumpers) and the buyers who made price-cost comparisons, too.

An interesting sidelight to the water-price-determination process in the two areas is that the firms with the smallest pumping output enjoyed the highest profit margin and those pumping the most water earned the lowest profit margin. A wider profit margin for less water suggests a stronger monopoly position of the pumper and a more economical use of water by the buyer.

These data prove that Taiwan farmers can and will pay substantially more for water than what Irrigation Associations have been charging. (Roughly NT$ 500 for Irrigation Associations and NT$ 6,000 for private pumpers.)

However, we have not yet determined the maximum farmers will pay, if necessary, to acquire water. In Chart 5 and Table 31, we can observe that as the price for water increased, the profit ratio diminished. For our pumping cases, this was due to two factors, higher costs of pumping and buyer resistance to higher prices. At some point, water prices can be too high and farmers will stay with dryland crops rather than irrigate. For rice farming, this transformation point appears to be about NT$ 10,000 per hectare per year. The average farm net-income ratio for rice and complementary crops was about 65 per cent when the water charge was NT$682

Chart 5. Water Price per One-inch Outlet Size per Year



Source: Table 31.

per hectare; at NT$ 10,000 per hectare for water, the net-income ratio would be about 48 percent. A water fee of NT$ 20,000 per hectare per year would drive the net-income ratio to zero. At the zero net-income level all of the farmers' net income from irrigated crops would be used for water payments and the incentive to change from dryland crops to irrigated crops would be eliminated. The water fee must be something less than the maximum if transformation of cropping patterns from lower- to higher-value crops is to be encouraged.

Summary

In this chapter we have attempted to define the terms, conditions, and standards of economic feasibility, priority, and repayability of irrigation projects, which we employ in the next chapter for evaluation of the Ta-Pu irrigation project. Economic feasibility is easily determined by benefit-cost analysis. The most difficult task is to decide which benefits and costs are to be included. The task is especially perplexing for the complex multi-purpose projects, for those in which private and public benefits and costs are interlocked, and for long-lived projects whose benefits are unduly influenced by commodity-price and land-use changes.

The wise selection among economically feasible projects for priority construction is essential if an economy with a limited capital budget is to grow at its maximum potential and inflation is to be controlled. Public projects need to be grouped according to their necessity and uniform priority standards applied within groups. For irrigation projects which yield tangible monetary benefits to private farmers, the internal rate of return on the total investment is considered to be the best measure of economic priority. Those projects yielding the highest rates of return should be undertaken first according to rank, if above the prevailing market rate of interest for such investments, and until the capital budget is exhausted; the other projects should be postponed until the capital budget is enlarged, the market rate of interest falls, or the internal rate of return rises.

There was no long-term, market-determined interest rate in Taiwan in 1962; an arbitrary 12 percent per annum was established by authorities as the cut-off rate for irrigation projects financed with public funds. The 12

percent rate was below the prevailing free-market rate for short-term loans, which made selection on the basis of the highest internal rate of return even more imperative. The rate of return can be determined easily and fairly if the costs and benefits are uniformly allocated and computed for each project. There was no central agency in Taiwan in 1962 authorized to make economic feasibility studies of and to determine priorities among water projects seeking public funds.

Taiwan water law requires that beneficiaries repay public investments in irrigation facilities. Repayability is generally based on average costs and revenues per hectare rather than on marginal costs and revenues for the water used by individual farmers. In general, large farmers receive above average revenues and could conceivably pay more for water received while small farmers, with below average revenues, must sacrifice part of their level of consumption to pay the water fee. Even so, Taiwan farmers were not paying full economic costs, let alone full marginal value, for the water received in 1962. The farmers belonging to Irrigation Associations paid less than NT$ 500 per hectare for water received in contrast to a few farmers in Southern Taiwan buying water from private-well pumpers who paid as high as NT$ 6,000 per hectare for their water supply.

CHAPTER V

TA-PU IRRIGATION PROJECT: A CASE STUDY

The Ta-Pu Irrigation project was selected for testing of economic feasibility, priority and repayability principles for a number of reasons. First, it was one of the few new major irrigation projects started and completed since Retrocession. Second, it was an expensive reservoir-irrigation project, more of which are planned. Third, Ta-Pu served a fairly small area, approximately 1,540 hectares, which simplified the sampling and computing problems of the restudy. Fourth, the actual costs and benefits had deviated widely from those planned and on which the project was justified. Fifth, the repayment assessments, as of 1962, were the heaviest of Taiwan's Irrigation Associations.

Before subjecting the project data to economic analysis, it seems appropriate to provide a brief description of the project, location, area irrigated and its relationship to surrounding areas. The statistics pertain to the situation as found in early 1962 or before.

Chunan Irrigation Association

The Ta-Pu project area constituted 26 percent of the 5,173 hectares in the Chunan Irrigation Association (See Chart 6). The Chunan Association was organized in 1940, but much of its area had been irrigated for many years before. Most of Chunan's irrigated area was in Miaoli hsien. The Taiwan Straits formed the western boundary of the Chunan irrigation area.

The Chung Kang river was the chief water source for the Chunan Association. The water for the Ta-Pu project was impounded behind a storage reservoir on a tributary, the Erh-mei creek. The topography of the area rises from sea level to 75 meters. The area is hilly and is interspersed with sharply eroded ravines. Most of the irrigated acreages are on sloping plateaus and stream bottoms.

The Chunan Association had 9,787 farm household members, and the

average size of farm was 0.53 hectares. However, some 40,000 separate plots were farmed in the area which means that, on the average, each family farmed 4 plots of land. In addition, the Association sold water to two large pulp-paper plants located within its boundaries.

IRRIGATED AREAS

The Chunan Association was composed of 34 separate irrigation areas that ranged in size from about 6 hectares to the 1,343 hectare Ta-Pu project. The next largest area was 1,226 hectare irrigated by the Long-un Canal, a diversion canal from the Chung-Kang river. These two areas constituted 50 percent of Chunan's total, the remainder being distributed among 32 areas. Each area was served by a separate irrigation system and a separate set of records was maintained for each area.

WATER FEES

The ordinary and special water fees assessed and collected in the Chunan Irrigation Association from 1950 to 1961 are indicated in Tables 32 and 33. The fees were assessed and collected in terms of rice until 1955 when cash payments were instituted.

The ordinary water fee, in NT$ equivalents, increased steadily after 1950. All members of the Association were made to share the added administrative and maintenance costs required by the new Ta-Pu project, begun in 1956. The 1962 fee was NT$ 550 per hectare. A large fee increase was imposed in 1960 as the added assessment for PWCB's joint construction fund. As we observed in Table 23, the Chunan Association's ordinary water fee per hectare in 1960 was below the average NT $ 412.47 of the 26 Irrigation Associations.

With respect to the special water fee, Chunan's per hectare special assessments were higher in all Associations. In fiscal 1960–61, it was collecting special water fees from farmers in three irrigation areas. The fee per hectare for the Ta-Pu area (1,343 hectares) was NT$ 3,100, for the Fung-Hsing canal area (112 hectares) NT$ 213, and for the Chien-Shan-Hsia canal area (273 hectares) NT$ 328. We may observe in Table 33 that the average special water fee assessment has varied from year to year. The Ta-Pu project assessment was the highest on record in the Chunan Irrigation Association.

As of early 1962, the total fee schedule per hectare, in the Chunan Irrigation Association, was as follows:

Name of project	Irrigated area (Hectares)	Total water fee (per hectare) NT$
Ta-Pu	1,343[1]	3,650[2]
Chien-Shan	273	878
Fung-Hsing	112	763
Others	3,445	550

[1] Actual assessments were made on only about 900 hectares. The remaining 440 hectares were still to be irrigated.

[2] NT$ 1,350 more for power cost ought to have been paid on 118 hectares irrigated by electric pumping but the Association was paying these costs from the ordinary fee collected from the pulp-paper companies.

In other words, a wide range in fee assessments prevailed within one Irrigation Association. This fee spread will exist, unless equalization assessments are made, until the loans for the three special projects are repaid.

The Association charged the two pulp-paper companies the same water rate per hectare (based on the number of hectares occupied) as charged farm users. One of the paper companies was located in the Ta-Pu irrigated area.

FINANCIAL CONDITION

The Chunan Irrigation Association had the higher total and per hectare indebtedness of all Associations in 1960 (Table 25). (Its ranking will be lowered as soon as the costs of some of the large reservoir projects underway are finally assessed.) Chunan's collection experience gradually deteriorated as the fees mounted (Tables 32 and 33), especially after collections were shifted from a rice to cash basis in 1955, and the Ta-Pu special water fee was imposed in 1960–61. The increase in delinquent accounts and in accounts receivable placed the Chunan Association in an embarrassing financial position. It was unable to meet all of its fixed obligations, and the management resorted to court action to force collections on individual accounts amounting to more than NT$ 1,000.* The delinquency

* The manager of the Association informed the writers that more than 700 accounts, as of June 1, 1962, had been sent to the court for collection. Not all were small-farmer delinquencies. The number represented 10 percent of all farmer members in the Association. The penalty for delinquencies was 10 percent of the amount due. The Association, however, had to stand all court costs and collection costs, if forced property sales were resorted to. The Provincial Government had under consideration a bill that would permit an 18 percent penalty, compounded, on all delinquent accounts, which would give the Associations much stronger fee-collection powers.

attitude of many farmers is understandable in view of the many years of irrigation subsidies and lax collections of water fees; farmers were conditioned to low water costs. The rather rapid increase in fees in the late 1950's created considerable resistance among farmers. Moreover, not all farmers were in favor of the special irrigation projects, at least as finally developed, or of an Island-wide joint construction fund. Also, by shifting fee collections from a rice to cash basis some farmers were unable to check their spending temptations in order to accumulate cash.

The Ta-Pu project, it is rather obvious, suddenly imposed heavy costs on certain benefited farmers. The initial repayment response was rather poor. The experiences in the Ta-Pu project should provide repayment and collection guidelines for some of the much larger projects underway.

A somewhat more detailed description of the Ta-Pu oject is needed here as background for the benefit-cost computations that follow. First, we present more details on the area irrigated. Next, a description of the irrigation system follows. Then, we make a brief statement of costs and planned benefits, and we conclude with a few remarks about the financing and repayment schedules.

AREA IRRIGATED

Of the 1,343 hectares in the Ta-Pu area, about 110 hectares were double-paddy and 200 hectares were single-paddy land before the project was constructed.* The rest was non-irrigated dry land. The paddy land was irrigated on a weather-dependent basis from water-catchment ponds. There were 381 ponds in the area, only four regulating ponds remained as part of the irrigation system.

The purpose of the project was to provide adequate water so that all 1,343 hectares might be farmed as double-paddy land. After completion, 161 hectares were to be served from the main canal, another 118 hectares of higher land reached with pumped water from the main canal, and the remainder irrigated from laterals. Approximately 160 of the project hectares were owned by the Taiwan Sugar Corporation. The Ta-Pu area was divided into 30 irrigation districts, averaging 45 hectares in size, for the rotational delivery of water.

* These figures are based on the original estimates of PWCB and differ greatly from JCRR's recheck, as shown in the following sections.

Table 32. Ordinary Water Fee Assessments and Collections in the Chunan Irrigation Association, 1950–1961

Fiscal year	Assessed areas (ha.)	Assessments (NT$)	Collections (NT$)	Assessments collected (percent)	Per hectare collections (NT$)
1950	3,508.54	232,808.40	175,024.70	75.18	49.89
1951	3,282.63	459,723.60	297,114.16	64.63	90.51
1952	3,259.51	457,084.80	404,457.98	88.49	124.09
1953	3,293.48	795,938.40	792,051.81	99.51	240.49
1954	3,321.11	797,930.00	404,676.73	50.72	121.85
1955	3,338.88	861,354.20	457,443.18	53.11	137.01
1956	3,305.36	857,974.20	434,990.10	50.70	131.60
1957	3,427.45	959,732.50	665,348.30	69.33	194.12
1958(1)	3,569.82	1,071,513.20	876,390.90	81.79	245.50
1960(1)	3,594.86	2,015,032.05	1,273,709.70	63.21	354.31
1961	4,981.33	2,468,009.20	1,478,056.00	59.89	296.72

(1) The absence of 1959 is due to a change in the identification of fiscal years from the year of beginning to the year of ending.

Source: Chunan Irrigation Association.

Table 33. Special Water Fee Assessments and Collections in the Chunan Irrigation Association, 1950–1961

Fiscal year	Assessed area (ha.)	Assessments (NT$)	Collections (NT$)	Assessments collected (percent)	Assessments per hectare (NT$)
1950	770.51	12,808.35	4,510.45	35.21	16.62
1951	763.31	25,527.60	9,466.00	37.08	33.44
1952	584.02	35,600.00	34,354.03	96.50	60.95
1953	569.63	70,162.40	61,731.79	87.98	123.17
1954	355.75	120,070.00	55,002.11	45.81	337.51
1955	1,096.50	30,663.70	—	—	27.96
1956	1,277.09	75,443.00	—	—	59.07
1957	—	448,012.58	391,052.18	87.29	—
1958(1)	178.64	191,443.00	174,353.40	91.07	1,071.67
1960(1)	757.73	260,542.10	204,416.10	78.46	343.85
1961	3,211.47	4,145,440.30	918,150.90	22.15	1,290.83

(1) The absence of 1959 is due to change in the identification of fiscal year from the year of beginning to the year of ending.

Source: Chunan Irrigation Association.

IRRIGATION SYSTEM

The heart of the Ta-Pu project is a concrete gravity-type reservoir, 21.4 meters in height with an effective capacity of 6,400,000 cubic meters of water, and a life expectancy of 50 years. It provides water to the Ta-Pu area by means of a 10.9 kilometer-long main canal, of which nearly

3.6 kilometers are tunneled in four stretches starting at the reservoir. The main canal was designed to serve 117 kilometers of laterals and sub-laterals and two pumping stations lifting water to 118 hectares of higher lands. Engineers placed an average useful life of 40 years on the main canal, 20 years on the laterals and sub-laterals, and 30 years on the pumping plants.

As was noted earlier, not all of the sub-laterals were completed as of June 1962. Many sub-laterals were being built by the Association.

Authorization for the construction of the reservoir and canals was given in mid-1956. The reservoir and principal canals were completed in June 1960.

COSTS AND BENEFITS

The original cost estimate for the completion of the reservoir, main canals and laterals, exclusive of canal right-of-ways and sub-laterals, was NT$ 40,000,000 (48). The Chunan Irrigation Association was to purchase all right-of-way and the farmers were to construct the sub-laterals. By the time the project was completed in June 1960, the actual project expenditure amounted to NT$ 61,643,352. (Appendix F, Table F-1).

The actual expenditures exceeded the planned for several reasons: (1) underestimation of engineering costs; (2) increase of construction time from three to four years, (3) price inflation of 8.3 percent per year; (4) delays in procuring right-of-ways; (5) unplanned-for necessity of lining canals, and (6) shifting of what were to be private construction costs to the Association.

In addition to the joint costs, a sizeable private reclamation investment was imposed on the farmers converting dry land to paddy land (approximately 395 hectares when fully irrigated). It was estimated from the Ta-Pu post-project farm survey that farmers invested an average of NT$ 13,500 per hectare converting dry land to paddy land, or a total investment of approximately NT$ 5,355,000 (at 1961 costs) to reclaim all 395 dryland hectares for irrigation. Most of these reclamation investments were required before farmers could benefit from the increased farm income.

The Ta-Pu project was authorized on the basis of a favorable benefit-cost ratio of 1:1.97. Annual costs were estimated to be NT$ 3,151,622 and

annual benefits NT$ 6,215,000. The benefits were measured in terms of 6,260 tons of added rice from the 1,230 hectares originally contemplated for irrigation. By the time the project was completed in 1960, the benefit-cost ratio had dropped to 1:1.5, chiefly because of the increased costs which included NT$ 6.7 million for interest (at 6 percent) on the construction outlays. If allowance had been made for changing cropping patterns and lower prices, the benefit-cost ratio would have been 1:1.11, or barely above the break-even level.

In terms of land-value changes, perhaps long-run benefits were underestimated. Dry land formerly selling at NT$ 15,700 per hectare increased in value virtually overnight to NT$ 109,700, after the project was underway, and prices on better double-paddy land rose to NT$ 150,000.

FINANCING AND REPAYMENTS

Project costs in excess of planned expenditures created unusual financial problems for the Chunan Irrigation Association. The solution, shown in Table 34, was a muddled financial operation that utilized four loans, three separate subsidies, two special assessments of all Association members, and unpaid obligations for right-of-way to certain Ta-Pu farmers, to cover all costs. Loans accounted for about 45 percent of total costs and came from four different sources. The loan terms called for 6 percent per annum with maturities ranging from three to 15 years. One result of such piecemeal financing was an uneven repayment schedule (Table 35) that required high early payments in order to amortize the short-term loans and to service the long-term loans at the same time.*

Private reclamation-cost financing was almost as varied. Many dryland farmers used their own funds; some borrowed short-term funds from the Land Bank at 14 percent per annum; others borrowed from the Provincial Food Bureau at 14 percent; while those obtaining funds from the rural credit cooperatives of the farmers' associations paid 16 percent per annum. The farmers who borrowed from their neighbors paid as high as 24 percent per annum for reclamation funds.

The original loan-repayment schedules for the Ta-Pu area are reported in Table 35. The revised schedules became effective in July 1962. The

* This study of the Chunan Irrigation Association's financial obligation resulted in a revised, and graduated repayment schedule, effective July 1, 1962.

Table 34. Financing the Ta-Pu Irrigation System[1]

Date funds obtained	Amount of funds (NT$ million)	Type of funds	Source of funds	Purpose of funds	Terms of funds
1956-58	20.2	Loan	JCRR	System construction	6% for 12 years.
1956-58	16.3	Subsidy	JCRR	System construction	—
1956-58	17.1	Subsidy	Provincial Government	System construction	—
1958	8.6	Loan	Land Bank from Provincial Irrigation Fund	Right-of-way purchase	6% for 4 years.
1960	3.534	Loan	Land Bank from Joint Construction Fund of Irrigation Associations	Right-of-way purchase	6% for 3 years.
1960	0.480	Assessment	Chunan Irrigation Association members	Right-of-way registration fees	—
1961	1.487	Notes payable	Ta-Pu farmers	Right-of-way purchase	Special water fees assessed note-holding farmers applied to amount owed them.
1962	0.835	Subsidy	Provincial Government	Laterals & sub-laterals	6% per year for 15 years.
1962	0.835	Loan	Joint Council of Irrigation Associations	Laterals & sub-laterals	6% per year for 15 years.
1962	0.090[2]	Assessment	Chunan Irrigation Association members	Sub-laterals and farm canals	—

[1] As of June 1962.
[2] Estimates.

Table 35. Special Water Fee Assessments for Ta-Pu Construction Loan Repayments, Original Schedules, 1959-71

Year of repayment	Special water fee paid per year (NT$)	Special water fee per hectare per year (NT$)	Assessed area (ha.)
1959	337,600	—	—
1960	859,919	3,086	—
1961	1,152,040	3,400	910
1962	2,749,997	2,500	1,100
1963	3,180,728	2,680	1,150
1964	3,360,038	2,800	1,200
1965	3,600,000	3,000	1,200
1966	3,937,482	3,150	1,250
1967	4,124,994	3,300	1,250
1968	4,485,994	3,450	1,300
1969	4,680,677	3,600	1,300
1970	5,880,409	4,200	1,343
1971	6,343,920	4,531	1,343

original special water fee schedule called for heavier payments at first until the short-term loans were repaid. The rate than was to decline until 1962 and gradually increase reaching a high of NT$ 4,531 per hectare in 1971. The revised schedule reduced the early payments and increased later payments. The closing maturity date was not altered. (As was noted earlier, the farmers obtaining water delivered by electric pumps were to pay an additional NT$ 1,350 per year per hectare for electric charges. All Ta-Pu farmers were to absorb the other pumping costs.)

The early high assessments, the heavy private investments for reclamation, and the right-of-way controversy with some farmers, resulted in a poor collection experience in 1960 and 1961, as is indicated below (Table 36).

Table 36. Ta-Pu Collections of Special Water Fee

Fiscal year	Crop	Assessments collected (percent)
1960	1st	39.2
	2nd	34.8
1961	1st	69.6
	2nd	63.2

The accumulating collection delinquencies forced the Irrigation Association to use reserve funds of the Association to meet its repayment commitments and to default on a portion of the due debt. Those farmers who were not paid for right-of-way were withholding payments and allowing their water bill to be deducted from the payment owing them for land. Even though the debt owed farmers was interest free, this practice upset the Association's debt-financing operations. As was noted earlier, the Association resorted to court action in some 700 cases not all were in the Ta-Pu area to obtain payment.

It is apparent that in spite of planned performances and contractual commitments, the Association could meet its goals and obligations only if the farmers responded according to schedule. The farmers did not respond as scheduled, which suggests that the plans were not realistic. Experience indicates that Taiwan farmers, in general, will meet their obligations if reasonable and realistic. In the final analysis, then, the burden for develo-

ping workable plans rests on the planners, administrators, and the institutional framework within which all must function.

It is appropriate now to re-examine the economic feasibility of the Ta-Pu project and to calculate the rate of return on the investment and the repayment capacity of the benefited farmers, according to the formulas proposed in Chapter IV, and based on a comprehensive re-study of Ta-Pu costs and benefits.

Economic Feasibility

An *ex-post* determination of economic feasibility necessitates the selection of a base year to which all recomputed costs and benefits can be related. 1960 was selected as the base year because: (1) water service from the Ta-Pu project was first provided in March 1961, and (2) field studies of farmers' costs-benefits were made in 1959 before project water was available and in 1961 after water was available. Therefore, certain costs such as dam construction costs occurring before 1960 were compounded forward to a 1960 present value and other planned costs and benefits occurring later were discounted backward to the 1960 base year. For compounding and discounting purposes, 12 percent per annum was used to conform to the new (1960) U.S. AID policy which called for a 12 percent interest rate on all new U.S. financed loan investments in Taiwan. (The original feasibility study employed a 6-percent discount rate.)

COST CALCULATIONS

The initial and large investment outlays occurred in the construction period 1956–60; smaller completion outlays were planned for 1961–63. By June 1960, the total construction costs of the reservoir and related facilities amounted to NT$ 28,684,950. The expenditure for other labor was NT$ 15,712,203 and for other materials NT$ 5,998,356. Expenditures for land, rights-of-way, and compensation for relocation of farm houses and damage to standing crops was NT$ 8,164,362.* Administration costs related to the construction of the project came to NT$ 3,083,481. The cost of investigations made prior to project authorization was excluded from the construction cost. The total construction outlays for the project amounted to NT$

* The original estimate for this expenditure was NT$ 8,703,980 but it was reduced by NT$ 539,618 in 1962 when part of the right-of-way was acquired by rental instead of purchase.

61,643,352 by 1960. The deferred costs for the construction of unfinished sub-laterals and the lining of major canals were estimated to be NT$2,337,000 by the end of 1963. These amounts were compounded or discounted at 12 percent to the 1960 present value of NT$ 74,395,159, as shown in Table 37. The area to be benefited, 1,542 hectares, was some 200 hectares more than originally planned due to the reclamation of land not previously cultivated.

Table 37. Estimated Annual Capital Outlays, Present Values, and Accrued Areas, 1956–1963

Year	Construction cost[1] (NT$)	Present value of construction costs, as of 1960 (NT$)	Accrued benefit area (ha.)
1956	2,577,173	4,056,470	—
1957	11,403,987	16,022,602	—
1958	9,341,493	11,714,232	—
1959	20,718,485	23,204,703	—
1960	17,602,215	17,602,215	758
1961	—	—	582
1962	1,537,252	1,225,497	122
1963	800,000	569,440	80
Total	63,980,605	74,395,159	1,542

(1) At 1960 prices after 1962.

Private farmers also expended NT$ 2,616,308 in 1961 on land reclamation in converting dry land to paddy land. Another NT$ 2.7 million is to be invested to reclaim an additional 395 hectares of land (Table 38 and Appendix F, Table F–2). Reclamation costs, although borne privately by reclaiming farmers and financed independently of the dam, canals, and right-of-way, are considered part of the total project costs.

The total amount of reclamation outlay estimated to take place in the 1961–64 period was approximately NT$ 5,354,620 at 1960 prices. The 1960 value of these costs was NT$ 4,294,653.

The economic life of the Ta-Pu project was determined by engineering estimates to be 50 years. With a 12 percent discount rate, the value of the dam and irrigation facilities at the end of a 50-year life expectancy period would be only 0.0035 of each NT$ of initial costs. In other words, the salvage value of the dam and irrigation facilities would be nearly zero at the end of 50 years. However, the present investment cost ought to be

adjusted by an allowance for the salvage value of land which would have value for other uses at the end of 50 years. The salvage value of land was estimated to be 80 percent of its initial cost (NT$ 4,401,644), with consideration given to the improvement and damage caused by the project. The estimated salvage value of land discounted to 1960 amounted to only NT$ 12,325.

Table 38. Estimated Annual and Total Reclamation Costs, by Private Farmers, 1961–1964

Year	Reclaimed land area[1] (ha.)	Reclamation[2] costs (NT$)	Present value, as of 1960 (NT$)
1961	193	2,616,308	2,336,101
1962	68	921,808	734,865
1963	67	908,252	646,494
1964	67	908,252	577,194
Total	395	5,354,620	4,294,653

(1) Estimated from survey data of 130 farms. See detailed statement about the farm economic survey in the next section.
(2) At 1960 prices.

By following the steps described above, the economic value of the 1960 investment costs for the Ta-Pu project was computed to be as follows:

(1)	Construction costs	NT$ 74,395,159
(2)	Reclamation costs	4,294,653
(3)	Salvage value of land	-12,325
	Net investment costs	78,677,487

BENEFIT CALCULATIONS

In order to conform to the costing period, the benefit period was begun at 1960 and irrigation benefits were assumed to continue for 50 years from 1961 to 2010. The benefits derived from the Ta-Pu project were roughly classified into two categories: direct and indirect irrigation benefits. These were further subdivided into tangible and intangible benefits.

Assumptions.—Before benefits could be calculated certain basic assumptions had to be made. First, that long-run commodity prices would be different than their 1960 prices. Second, that the 12 percent interest rate was a realistic discount rate. Third, that the cropping pattern in the

Ta-Pu area would become the same as the pattern in the adjacent irrigated areas.

As there was no equilibrium market price in Taiwan for farm products to reflect the real consumers' values, the producers' benefits were likely to be under-estimated. In order to rectify the unfairness of the controlled price mechanism, expected long-run prices of paddy rice, sweet potatoes, peanuts and vegetables were utilized in estimating benefits. Taiwan's long-run price of farm products stood at about 80 percent of the general price level in the period of 1910–1949 and about 70 percent in the period of 1950–1959. In 1960, the rice price increased by 40 percent more than did the general price level and other farm prices increased by more than 30 percent. The new 1960 farm-price level was relatively equal to the long-run trend of the general price level. To be on the safe side, however, the 1960 rice and sweet potato prices were reduced by 10 and 20 percent, respectively, to more nearly approximate their future long-run prices while no changes from 1960 prices were assumed for peanut and vegetable prices.

Even though the 12 percent discount rate was below the interest rate charged by Taiwan's financial agencies for short-term loans, it was adopted as an appropriate rate for discounting benefits and costs. As explained in Chapter IV, a 12 percent rate might be below the opportunity cost for such funds but any economic losses were expected to be at least partly offset by larger economic benefits than were originally anticipated.

The dominant crop pattern in the Ta-Pu area was expected to become similar to that in the older irrigated areas in the Chunan Irrigation districts. It was postulated that the national food consumption pattern would continue to shift to protein-contained foods and that the rapid increase of population would increase total rice consumption. Considering these two future demand trends and the reports made by farmers about their prospective land utilization, it was concluded that about 2,900 hectares of crop area would be planted to paddy rice, 450 hectares to sweet potato, 100 hectares to peanuts, and 225 hectares to vegetables after 1965. It was further assumed that the crop yields would be the same as in the neighboring irrigated areas.

Farm Survey.—Direct irrigation benefits were measured by the increased net farm incomes resulting from the application of project water. The

increase in farm incomes was obtained from a farm-economy survey of 130 sample farms, or roughly 10 percent of the total farm households benefited by the Ta-Pu project. The survey covered two periods, before and after irrigation, that is, 1959 and 1961.

Information on farm household populations, farm assets, crop patterns, yields, farm and non-farm receipts, farm operating costs and living expenses were obtained from the records of the 130 farm households. The general farm situations as portrayed by the farm-economic survey are shown in Table 39. For a fuller discussion of the sampling procedure and results see Appendix F, Table F-3.

Table 39. General Farm Situations Before and After Irrigation in the Ta-Pu Area*

	Before irrigation 1959	After irrigation 1961	Anticipated in 1964
Number of farms	1,417	1,475	1,530
Area of farm land (ha.)	1,585	1,664	1,664
Irrigated area (ha.)	758	1,340	1,520
Total crop area per year (ha.)	3,279	3,315	3,550
Orchard (ha.)	153	152	120
Reclaimed land area (ha.)	—	193	202
Size per farm (ha.)	1.12	1.13	1.09
Irrigated area per farm (ha.)	0 53	0.91	0.99
Capital investment per farm(NT$)	93,388	116,221	140,500

The total number of farm households after irrigation increased by 58 above the 1959 level. If farm households continued to increase at a rate of 1.4 percent per year, the total number would be 1,530 by 1964. Total farm area increased slightly after irrigation but no big increase was anticipated in the future.

* Comparing these figures with PWCB's estimates in the original plan, some discrepancies appear as shown below:

	Before irrigation, 1959				After irrigation, 1961		
	Total	Double paddy	Single paddy	Dry land & others	Total	Double paddy	Dry land & others
Original estimate (1)	1,343	110	200	1,033	1,343	1,343	—
Farm survey (2)	1,585	758	265	562	1,664	1,340	324
Difference (1)—(2)	— 242	— 648	— 65	471	— 321	3	— 324

Total paddy land, including double-and single-paddy land, was estimated as 1,023 hectares in 1959, of which 758 hectares were double-paddy land irrigated from water-catchment ponds and river-diversion canals and 265 hectares were weather-depending single-paddy land. The 381 ponds in the area before the project was constructed covered an estimated area of 87 hectares. After construction, only four regulating ponds remained. About 80 hectares of pond land was converted to arable land; the gain was offset by the loss of 80 hectares for right-of-ways. Some farmers, however, gained arable land while others lost it.

The total crop area, including the area planted to orchards, was increased by only 35 hectares after irrigation. Farmers reported that after 1963 their crop area would increase more rapidly with intensive farming and multiple-crop patterns. Farm area per farm decreased with the increase of total farm households in the area. However, irrigated farm area per farm increased from 0.53 hectare before irrigation to 0.91 hectare in 1961 and an estimated 0.99 hectares in 1964. These facts indicate that more intensive land utilization in the area can be expected after 1964.

Capital investment per farm amounted to NT$ 93,388 in 1959 and increased to NT$ 116,221 in 1961 and NT$ 140,500 is anticipated in 1964. Farm investments increased largely due to the rapid increase in land values after irrigation, and the construction of additional farm houses.

Table 40. Changes in Land Use Before and After Irrigation

	Before irrigation, 1959			After irrigation, 1961			Increase or decrease in production (1)—(2) m/t
	Planted area ha.	Yield per ha. kg.	Production (1) m/t	Planted area ha.	Yield per ha. kg.	Production (2) m/t	
1. Paddy rice	1,761	2,916	5,135	2,569	3,105	7,976	2,841
2. Sweet potato	1,130	6,941	7,843	497	7,043	3,500	— 4,343
3. Peanut	319	1,092	348	190	1,190	226	— 122
4. Sugar cane(1)	4	60,000	240	—	—	—	— 240
5. Other crops	65	3,233	210	59	4,889	288	78
6. Fruits and tea	153	—	—	152	—	—	—
Total	3,432	—	—	3,467	—	—	—

(1) Excluding Taiwan Sugar Corporation plantation farm. No change happened in crop pattern of TSC farm after irrigation.

The land utilization in the Ta-Pu area, as noted in Table 40, changed remarkably after irrigation. The planted area of paddy rice increased by

808 hectares and the plantings of sweet potatoes, peanuts, and sugarcane decreased. There was no big change in the planted area of other crops and fruits before and after irrigation. Yields of major crops also increased after irrigation. Yields increased by the following percentages: paddy rice by 6.5; sweet potato, 1.5; peanut, 8.9; other crops, 51.2. Comparing total productions before irrigation and after irrigation, we find that paddy rice increased by 2,841 metric tons, sweet potato decreased by 4,343, peanuts decreased by 122, while other crops increased by 78 metric tons.

DIRECT TANGIBLE BENEFITS

Direct tangible benefits of the Ta-Pu project were the increases in net economic values for farmers, industry, and the public resulting from the direct use of project water. The farm benefits, by far the most significant, were the increases in (1) level of family living; (2) cash income; and (3) farm investment.

The methodology employed for calculating benefits closely follows that of the Bureau of Reclamation of the United States Department of Interior. Total direct benefits of farmers attributed to the irrigation project were obtained by multiplying the average farm receipts and expenditure of sample farms in each survey district by the total number of farm households in that district before and after irrigation. The farm receipts and expenditures had to be computed for the base year of 1960 on the basis of the relative agricultural price levels prevailing before and after irrigation. Farm expenditures, however, did not increase in proportion to the rise in farm prices received (cf. page 107). The relative increase in farm receipts and expenditures between 1959 and 1961 were deflated with ratios of 1.1412 and 0.9689, respectively, in determining the 1960 level of prices.

The gain in farm income included the increased income from rice and other crops sold and consumed on farms, minus the increase in the following items: (1) cash production expenses; (2) depreciation of production equipment; (3) interest on farm investment; and (4) allowances for family living.

Direct farm benefits were calculated from the summaries of the farm-economy data representing before and after irrigation as shown in Table 41. For a detailed statement of discounted farm incomes and expenditures for

Table 41. Derived Direct Annual Farm Benefits from the Ta-Pu Project[1]

Unit: NT$

Item	After irrigation, 1961	Before irrigation, 1959	Difference	Annual benefits
Number of farms	1,475	1,417	58	
Area of farm (ha.)	1,664	1,585	79	
Irrigable area (ha.)	1,340	758	582	
A. **Increase in family living**				
1. Farm products consumed	12,557,351	9,105,596		
2. Livestock consumed	1,319,215	1,243,358		
3. Rental value of dwelling	2,473,387	2,439,328		
4. Cash expenditure for family living	16,756,502	18,783,737		
5. Total used for family living	33,106,455	31,572,019	1,534,436	
6. Less additional cash income from non-farm sources	9,678,460	10,584,353	— 905,893	
7. Net increase in family living	23,427,995	20,987,666	2,440,329	A. 2,440,329
B. **Increase in cash income**				
8. Farm products sold	14,935,058	9,705,834		
9. Livestock sold	6,165,600	8,251,206	4,103,084	
10. Increased value of crops & livestock	1,288,266	326,800		
11. Minus, cash production expenses (excluding water fee and land rent)	7,791,767	6,622,901		
12. Minus, depreciation	1,515,167	1,130,722		
13. Minus, hired labor expenses	2,550,739	1,874,282		
14. Minus, interest on investment	1,333,455	1,249,478	1,192,403	
15. Minus, cash for living (less cash income from non-farm sources plus rental value of dwelling)	7,078,042	8,199,384		
16. Net increase in cash income	2,117,754	— 792,927	2,910,681	B. 2,910,681
C. **Increase in investment**				
17. Investment on farms	195,835,269	158,483,980	37,351,289	
18. One percent of increase in investment	—	—	373,513	C. 373,513
19. Total direct benefits of farmers	—	—	—	5,724,523
20. Average direct benefits farmers per ha. of irrigable area	—	—	—	4,272
21. Industrial and public water supply	577,848	—	—	D. 577,848
22. Maintenance and operation costs of irrigation facilities	714,079	296,256	417,823	
23. Total net direct benefits	—	—	—	E. 5,884,548

[1] All farm receipts and expenditures adjusted to a 1960 price level.

Sources: "Farm-Economy Survey of the Ta-Pu Area," Provincial Water Conservancy Bureau and Joint Commission on Rural Reconstruction, 1962. Table design follows U. S. Department of the Interior, Reclamation Manual 2.2.3. (42).

the 1961–2010 period see Appendix F, Table F-4.

The total direct benefits to Ta-Pu farmers was estimated as NT$ 5,724,523 annually.* On a per hectare basis of irrigable land, it amounted to NT$ 4,272. The increase in family living accounted for nearly 40 percent of the total benefits, reflecting the small subsistence farming prevailing in the area. About 55 percent of the gain was attributed to an increase in net cash incomes and the remaining 5 percent to farmers' increased farm investment. Not only did the Ta-Pu farmers enjoy a substantial increase in their family living but also they were able to reduce their living expenditures from cash income. Cash income before irrigation (item 16, Table 41) was negative chiefly because unpaid interest on investment and depreciation were included as expenses.

The repayment of project loans depends on cash income. Cash income after irrigation was calculated to be NT$ 2,910,681. We have reason to believe that the farmers' cash incomes will increase in the years ahead as more land is reclaimed, cropping patterns change in response to higher net returns, and as a smaller proportion of the gains go to increased farm-family consumption. Recognition needs to be given, however, to the continued increase in the number of farm families operating smaller farms and earning lower cash incomes per farm. If inflation, even at a nominal rate, were allowed to be recognized in benefit-cost computations, the future net benefits to Ta-Pu farmers would be substantially greater than these postulated in Table 41.

The Ta-Pu water development plan provided for water service to local paper mills and eventually to nearby communities. According to the bilateral agreement between the Chunan Irrigation Association and the two paper mills, the per hectare water rate charged the mills was to be NT$ 3,400 plus NT$ 640 of ordinary (Irrigation Association overhead) expenses. A total of 86.2 hectares was agreed upon as the basis of total water use for calculating their total water fee.

The township offices of Tou-fen and Chunan plan to use Ta-Pu water by 1965. The total quantity of supplemental water supply needed amounts to 10,000 M. T., which is to provide 50,000 people with 0.12 CMS. We

* The total benefit was lower than anticipated before construction because the irrigable potential was overestimated: more land than estimated was already in double paddy (see footnote table on p. 108).

assigned a unit price of NT$ 0.4 per M. T. to the public water, and 10 percent as the rate of net benefit to the public-water enterprises. The direct benefit of the public-water supply was deferred to 1965; the estimated value in 1965 was discounted at 12 percent to a 1960 present value estimated to be NT$ 577,848 annually.

The total stream of estimated annual benefits (farm, industry and public) for the 50-year is indicated in Table 42 (see also Appendix F, Table F-4). The annual discounted benefits were expected to increase from 1962 to 1965 and then to decrease year by year. Total direct benefits accumulated during the 50-year economic life of the project amounted to NT$ 87,348,131. This total was predicated on the assumptions that (1) farm prices and costs remain at the 1960 level; (2) no increase in irrigable area after 1965, (3) crop patterns remain as in 1965; and (4) no improvement in the management ability of farmers. Past experience suggests that none of these factors remain constant. Over the years, direct benefits are likely to increase steadily above the predicted level. Costs, in view of the large initial fixed investment, are not likely to rise as much as benefits.

There are other direct though less tangible benefits expected from the Ta-Pu project. The greater security of the water supply, for example, will enable farmers to plan further ahead and to eliminate costly risk-hedging operations. Furthermore, the farmers' improved diets should increase their labor productivity, and larger product sales off the farms should lead to lower marketing costs and to larger net returns to farmers.

INDIRECT BENEFITS

Indirect benefits are the net-income benefits accruing to other than the direct beneficiaries as a result of the increased flow of agricultural products or services from the project. The indirect benefits attributable to the Ta-Pu project were divided into three categories: (1) profits of all local private enterprises from handling, processing, and marketing the increased volume of farm products; (2) benefits to the Provincial Food Bureau (PFB) handling the increased paddy rice and selling of fertilizers through the barter-exchange system; and (3) benefits of fishing in the reservoir.

Tangible Indirect Benefits.—The United States Bureau of Reclamation (42) assigns 5 percent as the factor representing the share of gross profits

Table 42. Estimated Annual Stream of Direct Benefits Accruing During the Economic Life of the Ta-Pu Project, 1961–2010[1]

Period of analysis Year	Year	Net farm earnings NT$	Maintenance & operational costs of project NT$	Net benefits of irrigation NT$	Additional increase of net benefits of irrigation NT$	Net benefits from industrial and public water supply NT$	Total net benefits from water supply NT$	Total net direct benefit discounted to 1960 at 12 percent per annum NT$
0	1959	28,282,836	296,256	27,986,580	—	—	—	—
1	1961	34,530,549	714,079	33,816,470	5,829,890	348,248	6,178,138	5,516,459
2	1962	34,683,425	714,079	33,969,346	5,982,766	348,248	6,331,014	5,047,084
3	1963	36,925,197	714,079	36,211,118	8,224,538	348,248	8,572,786	6,102,109
4	1964	38,619,201	714,079	37,905,122	9,918,542	348,248	10,266,790	6,524,545
5	1965	40,133,526	714,079	39,419,447	11,432,867	748,248	12,181,115	6,911,565
6	1966	40,133,526	714,079	39,419,447	11,432,867	748,248	12,181,115	6,170,953
7	1967	40,133,526	714,079	39,419,447	11,432,867	748,248	12,181,115	5,509,518
8	1968	40,133,526	714,079	39,419,447	11,432,867	748,248	12,181,115	4,919,952
9	1969	40,133,526	714,079	39,419,447	11,432,867	748,248	12,181,115	4,392,510
10	1970	40,133,526	714,079	39,419,447	11,432,867	748,248	12,181,115	3,922,319
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
20	1980	40,133,526	714,079	39,419,447	11,432,867	748,248	12,181,115	1,263,182
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
30	1990	40,133,526	714,079	39,419,447	11,432,867	748,248	12,181,115	406,849
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
40	2000	40,133,526	714,079	39,419,447	11,432,867	748,248	12,181,115	130,338
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
50	2010	40,133,526	714,079	39,419,447	11,432,867	748,248	12,181,115	42,634
Accumulation (1-50)		1,990,900,568	35,703,950	1,955,196,618	555,867,618	35,812,400	591,680,018	87,348,131

[1] For detailed statistics see appendix F, Table F-4.

of local processing plants attributable to the increased volume of farm sales. In this study, 6 percent of gross profit was estimated to be an indirect benefit.*

Benefits to PFB from the collection and handling of the increased paddy rice and fertilizer were calculated from farm-budget summaries representing the farm situations before and after irrigation. Benefit factors of 30 percent and 21 percent, respectively, were assumed for rice collection and paddy-fertilizer exchange benefits of PFB. The total PFB benefits represent the price margins between the PFB's rice price and the market paddy price, and PFB's average cost price and allocation price for fertilizer. (The figures of 30 percent and 21 percent were derived from the statistics presented in references 33b and 49.)

Benefits from fishery production in the Ta-Pu reservoir were calculated on the basis of the original project plan as drawn up by the Chunan Irrigation Association. The plan anticipated that the annual total fishery production would amount to 117,500 kg. Receipts would be NT$ 1,261,400 and expenditures NT$ 304,500, on the basis of 1960 average prices. The annual net income from fish production was estimated at NT$ 956,900. The fishery benefits, however, would not begin until 1963. The expected benefits in 1963 and later were discounted to a 1960 present value.

Annual indirect benefits attributed to the increased sale of farm products, use of fertilizer, and fishery production were NT$1,624,125, as shown in Table 43. The largest indirect benefit went to the Provincial Food Bureau from the collection of paddy rice and the paddy-fertilizer exchange. In a free-market situation, all or most of these benefits would accrue to the farmers as direct benefits less, of course, an increase in their taxes.

The total value of indirect benefits discounted to 1960 at 12 percent per annum was calculated te be approximately NT$18,744,821, or about 21 percent of the total annual direct benefits. The stream of annual and discounted indirect benefits from 1961 through 2010 is presented in Appendix F, Table F-5. The annual stream of indirect benefits through the project's economic life might change from year to year. Changing crop and land-use patterns would alter indirect benefits as well as the direct benefits.

* The 6-percent factor was derived from "Marketing Statistics of Farm Products in Taiwan" reported by JCRR and published in Economic Research Bulletin No. 75, Bank of Taiwan, 1962.

Table 43. Annual Indirect Benefits Attributed to the Ta-Pu Irrigation Project[1]

	After irrigation (NT$)	Before irrigation (NT$)	Difference (NT$)	Benefit factor (Percent)	Annual benefit as of 1960 (NT$)
A. **Sale to local enterprise**					
Farm products sold	17,642,561	11,746,252			
Livestock sold	6,165,600	8,251,206			
Sub-total			3,810,703	6	228,642
B. **Benefits of PFB**					
Collection of paddy	1,908,667	1,258,663	650,004	30	195,001
Paddy-fertilizer exchange	5,984,531	3,511,379	2,473,152	21	519,362
Sub-total					714,363
C. **Benefits from fishery**	681,120	—	681,120	100	681,120
Total indirect benefits					1,624,125

[1] See Appendix F, Table F-5 for further details.

Intangible Indirect Benefits.—Intangible benefits are described by the U. S. Bureau of Reclamation Manual (42) as the increase in the production of goods and services and the improvements in general welfare which cannot be measured adequately in monetary terms. Generally speaking, intangible benefits are public benefits and are broadly disseminated. For discussion purposes we classified such benefits under four major headings: (1) employment opportunities; (2) investment opportunities; (3) community facilities and services; and (4) economic stabilization.

The additional employment opportunities were estimated at 10,000 man-days per year of farming and about an additional 5,000 men-days per year in the related non-farm businesses. These employment opportunities were expected to continue for the laborers throughout the life of the project. Additional wages to farm labor after irrigation, assuming no change in future wages, amounted to some NT$680,000. By applying a wage difference of NT$15 per day between farm employment and non-farm employment, total non-farm wages paid approximated NT$75,000. Hence, the $755,000 per year are the total added wage payments attributed to the project. The employment effect on less directly affected enterprises was not as easily ascertained.

The investment opportunities created by the project were hard to enumerate, because of the difficulty of showing or proving the absence of

alternative investment opportunities for such a long period. Although the induced investment opportunities in farm improvements, construction of rice mills, and other factories were expected to increase, the benefits were difficult to identify. It could well be that other investments of a like amount might have yielded the economy greater benefits.

With respect to added community facilities and services, the U. S. Bureau of Reclamation suggests using the estimated increase in real and personal property taxes as a measure of such benefits. In the case of the Ta-Pu project, income and land taxes were not collected by local governments for improving community facilities and services. Increased taxes, including income and land taxes, were estimated to be roughly NT$1,544,400 annually after final production adjustments were made. New social construction, wildlife expenditures, roads, and other services were expected to increase in the Ta-Pu district after construction of the project, but these benefits were difficult to estimate.

The impact of the Ta-Pu project on economic stabilization was also difficult to estimate. Irrigation provides economic stabilization by eliminating the effects of a drought for example. Eckstein suggested that the value of such benefits be arbitrarily set at 5 percent of direct benefits, and where stabilization is desperately needed, 10 percent of the direct benefits might be allowed (2). In the case of Ta-Pu, a steady supply of water was not available before irrigation. Most of farmers depended on ponded rain water which was uncertain and a wide variation in rice yields resulted. We applied 10 percent of the annual total direct benefits as the benefits of economic stabilization stemming from the Ta-Pu irrigation project, and the total amounted to NT$640.77 annually.

The quantification of indirect benefits in monetary terms, though incomplete and approximate, provides a basis for giving priority to projects with like direct benefit-cost ratios and for determining a subsidy amount, if necessary. The intangible benefits must of necessity be omitted from benefit-cost ratios and comparisons.

SUMMARY OF BENEFIT AND COST CALCULATIONS

The cumulative net benefits and costs of the Ta-Pu irrigation project throughout its economic life of 50 years (1961–2010) are summarized in Table 44.

Table 44. Summary of Cumulative Life-Time Net Benefits and Costs for the Ta-Pu Project, 1961–2010

1.	Direct farm benefits	NT$ 591,571,568	
	Industrial and public water supply	35,812,400	
	Less maintenance and repairing costs	35,703,950	
	Total net direct benefits		591,680,018
2.	Indirect benefits		
	Increased profits from sale of farm products and livestock	25,600,113	
	Increased profits from collections and exchange of paddy by PFB	70,240,717	
	Fishery benefits	32,693,760	
	Total net indirect benefits		128,534,590
3.	Total direct and indirect benefits		720,214,608
4.	The 1960 discounted direct net benefits	87,348,131	
5.	The 1960 discounted indirect net benefits	18,744,821	
6.	The 1960 discounted benefits=4+5		106,092,952
7.	(a) Total construction costs discounted to 1960	74,382,834	
	(b) Farmers' reclamation cost discounted to 1960	4,294,653	
	(c) The 1960 discounted costs		78,677,487
8.	Present worth (1960)=6-7[1]		27,415,465

[1] All costs and benefits were discounted at 12 percent to arrive at 1960 values.

The above summary table shows that the present worth (1960) was positive at a discount rate of 12 percent. Hence, the Ta-Pu irrigation project was economically justified. Even if we limited the comparison to the total net direct benefits accrued by the project to the initial construction costs, present worth remained positive, indicating that the Ta-Pu project had high economic benefits. If we were to take the intangible benefits into consideration, the economic feasibility of the Ta-Pu project would be considerably higher.

The benefit-cost ratio, if indirect benefits are excluded, would be 1:1.11 (present direct benefits of NT$ 87,348,131 divided by present costs of NT$ 78,677,487). If indirect benefits are included, the ratio would be 1:1.35. These positive ratios merely reaffirm the economic feasibility of the Ta-Pu project even if intangible benefits are excluded.

By separating the total net benefits into private and public categories, we found that private benefits totalled about NT$ 555,867,618 while public benefits amounted to NT$ 131,653,230, or 81 percent and 19 percent, respectively, of the total benefits. The breakdown is shown in Table 45.

Table 45. The Cumulative Private and Public Irrigation Benefits, 1961–2010

1. Private net benefits		
Direct farm benefits less irrigation maintenance and repair costs	NT$	555,867,618
2. Public benefits		
Industrial and public water supply		35,812,400
Increased profits from sales of farm products and livestock		25,600,113
Increased profits of PFB from handling the paddy rice		70,240,717
3. Total benefits		687,520,848

Both private and public net benefits are considered to be available and responsible, in proportion to their share of the total, for the repayment of construction costs. Farmers, therefore, should not be expected to repay more than about 81 percent of the total project costs.

ALTERNATIVE DISCOUNT RATES

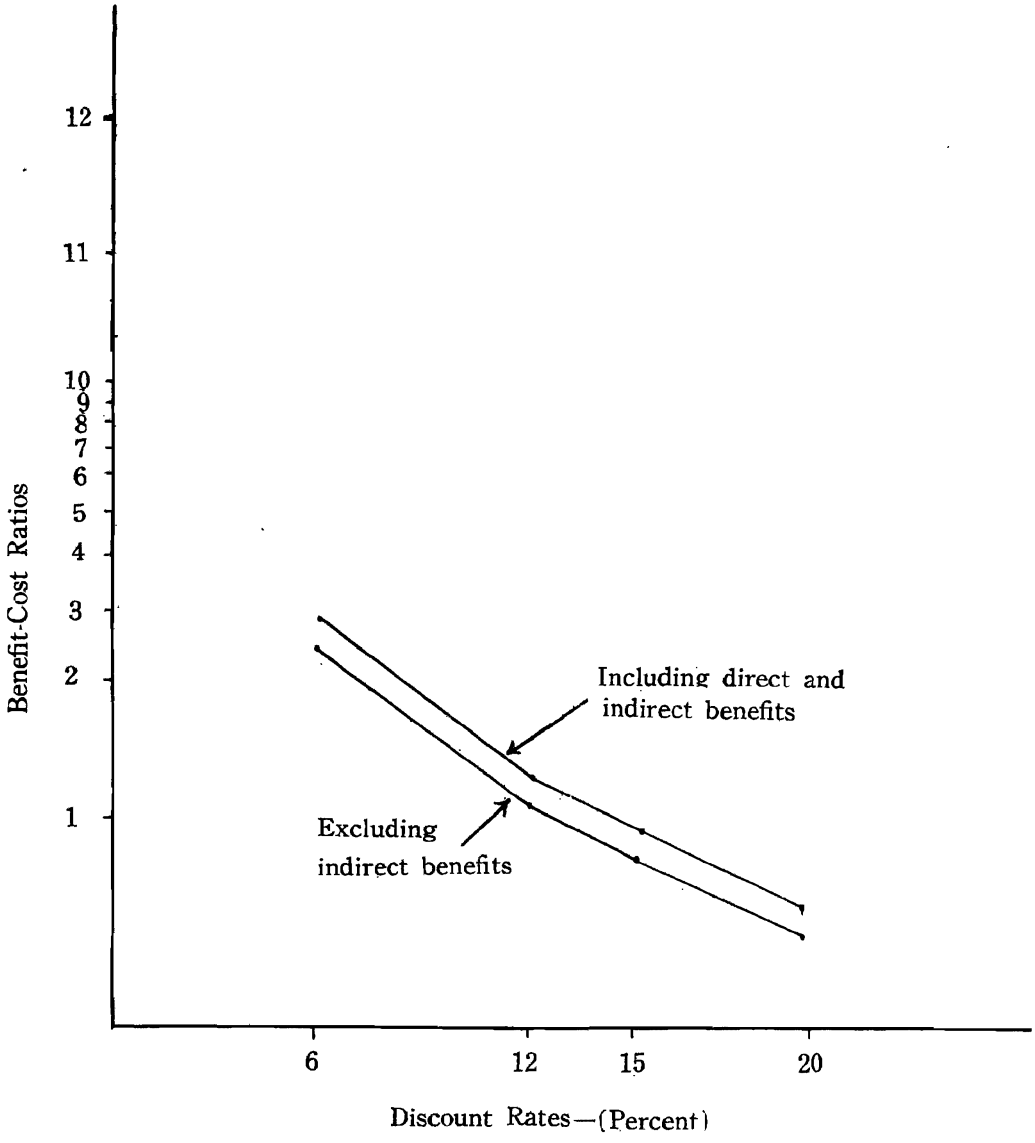
In this section, we vary the discount rates in order to test their effects on the benefit-cost ratios and to determine the interest rate level at which the present worth is reduced to 0. For these purposes, we employed 6, 12, 15 and 20 percent interest rates for discounting the annual stream of benefits and the deferred costs of construction throughout the project's economic life back to 1960, the base period for the analysis.

Table 46. Alternative Discount Rates and Their Effects on Benefit-Cost Ratios for the Ta-Pu Project, as of 1960

	Discounting rates—percent			
	6	12	15	20
Construction costs NT$	68,938,022	74,395,159	76,697,628	82,497,722
Reclamation costs NT$	4,770,626	4,294,653	4,088,630	3,783,926
Less salvage value of land NT$	137,331	12,325	3,169	352
Total investment costs (1) NT$	73,571,317	78,677,487	80,783,089	86,281,296
Direct net benefits (2) NT$	176,583,039	87,348,131	68,019,347	48,825,786
Indirect net benefits (3) NT$	38,169,556	18,744,821	14,538,341	10,363,227
Total net benefits (4)=(2)+(3) NT$	214,752,595	106,092,952	82,557,688	69,189,013
Benefit-cost ratio				
(2)/(1)	2.40	1.11	0.84	0.57
(4)/(1)	2.92	1.35	1.02	0.80

An increase of the discount rate, as shown in Table 46, reduces the

Chart 7. Effect of Varying Rates of Discount on Benefit-Cost Ratios



benefit-cost ratios. At the 12 percent discount rate the direct benefit-cost ratio is near the breakeven point or at which the project is just economically feasible. If the indirect benefits are included, the project remains economically feasible at a 15 percent discount rate but not much beyond.

We may conclude from the above data that regardless of the discount rate used the benefit-cost method is consistent in the ranking of projects; the project with the highest ratio remains so. Chart 7 shows us that the benefit-cost ratio is not haphazardly affected by the rate of discount. The benefit-cost ratio, however, indicates only whether a project is economically feasible, it does not tell us the rate of return that borrowers earn and the rate they could pay for funds invested in the project.

INVESTMENT RETURN

To determine the rate of return on the Ta-Pu investment, we turn to the data presented in the preceding table. We may observe that at the 12 percent rate the direct benefits (only direct benefits were available for the repayment of borrowed funds) substantially exceeded the costs of construction. These facts suggest that the rate of return on the Ta-Pu investment was higher than 12 percent per year. A trial-and-error method was adopted to obtain the maximum internal rate of return which would reduce benefits minus initial costs to zero. The superiority of utilizing this method in Taiwan was detailed in Chapter IV. By trial-and-error, we note that the 15 percent discount rate reduced the 50-years of direct benefits to NT$ 68,019,347 and the costs to NT$ 80,783,089. The 15 percent rate reduced the value of benefits below costs. The 12 percent rate, we discover, resulted in direct benefits exceeding costs by nearly NT$8.7 million. The third trial revealed that 13 percent approximated the appropriate rate of return.

The 13 percent rate was more than one percent higher than the 12 percent charged by AID authorities on United States loan funds and was slightly less than the 14 percent paid on bonds issued by the Free China government. On the other hand, a 13 percent rate was substantially below the prevailing market rate of interest, even for short-term funds, in Taiwan. A higher future rate of return could be anticipated with improved cropping patterns and management practices.

Farmers Repayment Capacity

It appears from the data presented that the Ta-Pu farmers would have no difficulty in repaying the total costs of the Ta-Pu project including an interest rate of 12 percent per annum. (It will be recalled that the Ta-Pu farmers were to repay only 46.5 percent of the total project cost in 13 years at a 6 percent rate.)

In calculating the economic benefits of the project, incremental living expenditures attributable to irrigation were included in income benefits. Farmers' repayment capacities are more appropriately related to cash incomes, however. According to our analysis, the average cash repayment capacity per farm household in Ta-Pu was NT$ 4,144 or NT$ 3,667 on a per hectare of irrigable area, as shown in Table 47. Comparing average incremental farm income of NT$ 6,894 per household, repayment capacity per hectare was only 60 percent of total farm income. About 40 percent of additional farm income after irrigation was used for increasing living levels.* In the Ta-Pu area, farmers' living expenses before irrigation were NT$ 17,069 per farm household which was about 80 percent of the average amount for all farm families in Taiwan. The amount of the incremental income used for family living depended not only on the levels of living before irrigation and the cost of irrigation but also on the size of farm per farm family.

REPAYMENT CAPACITY AND FARM SIZE

The variation of farmers' repayment capacity by different farm sizes may be seen in Table 47.

It is obvious that farmers' repayment capacity markedly increased as the size of farm increased. On a per hectare basis, the average repayment capacity amounted to NT$3,667 which was much less than the capacity of the farms of 3.0-5.0 hectares and larger than for the 0.5-1.0 hectare-sized farms. The NT$3,667 was about 8 percent higher than the NT$3,400 per hectare required of Ta-Pu farmers as the first installment repayment in 1961. Only farmers cultivating 1.0-3.0 hectares or more of

*It should be restated here that farmers' "after irrigation" living expenses determined in the Ta-Pu farm-economy survey were based on the terms of the actual loan (46.5 percent of total costs and a 6 percent interest rate) [i]f the repayment terms had been more severe the farmers' level-of-living after irrigation would likely have been lower.

farm area were able to repay this predetermined amount from added income.

Table 47. Ta-Pu Farmers' Repayment Capacity, by Farm Size

Farm size (ha.)	Farms (no.)	Average irrigable area (1) (ha.)	Incremental farm receipts (NT$)	Incremental farm expenses (NT$)	Incremental net farm income (NT$)	Living allowance (NT$)	Repayment per farm household (2) (NT$)	Repayment (2)/(1) capacity per ha. (NT$)
Less than 0.5	184	0.35	2,385	1,265	1,120	453	667	1,905
0.5—1.0	639	0.80	5,650	2,410	3,240	1,653	1,587	1,983
1.0—3.0	590	1.49	18,253	6,021	12,232	5,017	7,215	4,842
3.0—5.0	62	3.30	41,555	15,837	25,718	6,572	19,146	5,801
Average	1,475	1.13	12,359	5,465	6,894	2,750	4,144	3,667

Source: Appendix G, Table G-1.

REPAYMENT CAPACITY AND LAND CLASS

The repayment capacity of farmers was strongly affected by the class of land they cultivated before irrigation. In the Ta-Pu area, dry land before irrigation was mostly used to grow sweet-potato, peanut, and some to grow sugarcane and other crops. The single-paddy land before irrigation was used to plant one season of paddy and one season of sweet-potato. The double-paddy land was cultivated twice for the planting of paddy rice before and after irrigation, and was the expected land class after irrigation. A comparison of debt-repayment capacities of farmers cultivating different land classes is made in Table 48. (The supporting statistics are available in Appendix G, Table G-1.)

Table 48. Ta-Pu Farmers' Repayment Capacity, by Type of Land Class

Land class before irrigation	Land class after irrigation	Incremental farm receipts per ha. (NT$)	Incremental farm expenses per ha. (NT$)	Incremental living expenditures per ha. (NT$)	Repayment capacity per ha. (NT$)
Dry land	Double-paddy land	14,691	7,360	3,065	4,266
Single-paddy land	Double-paddy land	7,744	4,150	1,438	2,156
Double-paddy land	Double-paddy land	2,400	—	720	1,680
Average		10,937	4,836	2,434	3,667

As no farmers cultivated only one type of land class in the Ta-Pu area, the above estimates were made on the basis of average crop patterns and yields by land classes. Incremental living expenditures per farm per hectare were assumed as 50 percent of the total living expenses for dry land before irrigation, 40 percent for single-paddy land and 30 percent for double-paddy land.* The average figure was obtained by weighting expenses according to the land area in the different land classes.

The above analysis shows us that the dry land converted by irrigation to double-paddy had a much larger repayment capacity than either the single-paddy or double-paddy land. As so much of the land before irrigation was already in double paddy, the repayment capacity of the whole project was considerably smaller than originally anticipated. Since dry-land farms were larger than double-paddy farms (see Table 48 and Table 4a), the farmers converting dry land to paddy had a much larger repayment capacity, because of larger increases in farm receipts, than did double-paddy farmers. The former dry-land farms are likely to be reduced in size after irrigation. The pre-irrigation dry-land farmers incurred an average reclamation cost of NT$13,500 per hectare**, which, because of the increased income derived from irrigation, was a profitable investment.

REPAYMENT CAPACITY AND RETURN ON INVESTMENT

Another approach to repayment capacity is to determine the rate of return on farm investment induced by an increased and stable water supply. Theoretically, the marginal rate of return on investment among farms is a better measure of investment efficiency than is the average rate of return. Moreover, the marginal rate is comparable to the market rate of interest on investment funds, which is determined by the marginal efficiency of a variety of investments, including investments in irrigation projects.

Certain assumptions and statistical restatements are necessary in order to determine the marginal rate of return on irrigation investments for Ta-pu farmers. Inventory accumulation on farms before and after irriga-

*The ratios of 50 percent, 40 percent and 30 percent were based on the facts obtained from the farm-survey income-expense data, classified by different types of land categories.

**The amount of NT$15,400 per hectare of the reclamation costs was the average for all of the survey farms in the Ta-Pu area.

tion was measured in real terms and then converted to dollar amounts. The increases in land values were attributed to the irrigation investment. Production expenses were modified to include an imputed wage for family labor. The return to capital included not only a return to incremental farm capital but also an undetermined amount for farm management. Depreciation of capital remained as a cost.

The marginal rate of return on investment for all Ta-pu farms was computed to be 9.53 percent, as indicated in Table 49. The larger the farm size the larger the return. The farms of three hectares or more experienced a marginal rate of return of over 16 percent. These low rates seem inconsistent with the internal rates of return calculated above (p. 119) on the basis of project direct benefits and project costs.

Table 49. Marginal Rate of Return on Farm Investment, by Different Farm Sizes, Before and After Irrigation, in 1960

Farm size ha.	Incremental receipts (NT$)	Incremental expenses (NT$)	Living allowance (wage for family labor) (NT$)	Incremental capital return (NT$)	Incremental capital invested (NT$)	Marginal rate of return on investment (percent)
Less than 0.5	2,385	1,265	453	667	12,008	5.55
0.5-1.0	5,650	2,410	1,653	1,587	24,355	6.52
1.0-3.0	18,253	6,021	5,017	7,215	55,818	12.93
3.0-5.0	41,555	15,837	6,572	19,146	119,087	16.08
Average	12,359	5,465	2,750	4,144	43,503	9.53

The difference between the two types of returns is due largely to the values used for computation—farm capital here versus project investments earlier. The major factor accounting for the low rate of return on farm capital was the inclusion of the increased land value after irrigation as farm capital. The average increase of land value, including irrigated and non-irrigated land, amounted to NT$24,000 per hectare. The change from dry land to double paddy increased land values from NT$15,700 to NT$109,700, as may be observed in Table 50.

On a per farm-household basis, the total increase in capital investment amounted to NT$ 43,503 (table 49). About 3 percent of the increase was

attributed to the addition of farm houses, implements, and livestock, and 97 percent to an increase in land value, which resulted from the assurance of more secure water, reclamation of land, and a bit of inflation. It should be noted here that if the Tu-Pu farmers had been required to repay all project costs and at an interest rate of 12 percent per annum, it is highly unlikely that land values would have increased to the levels reported. Any reduction in farm capital values would have resulted in a higher average marginal return on investment than 9.53 percent.

Table 50. Ta-Pu Land Prices Per Hectare Before and After Irrigation

	Before NT$	After NT$	Difference NT$
Double-cropping field	82,600	109,700	27,100
Single-cropping field	69,000	72,500	3,500
Dry land	15,700	19,100	3,400

Repayment capacities, with a 40-percent allowance for family living, ranged from a low of NT$1,405 per hectare to a high of NT$6,200; a median of NT$3,412 and an average of NT$ 3,667.

If Ta-Pu farmers were asked to repay total construction costs only, disregarding the private reclamation, maintenance and operation costs, discounted at 12 percent per annum, the average annual repayment amount required for 50 years would have been NT$ 4,996 per hectare. If the private reclamation and maintenance-operation costs were included, the average annual amount required would have increased to NT$5,483 per hectare (table 51). The amount required would have increased as the repayment period was shortened.

A comparison of the above averages indicates that the Ta-Pu farmers with above-average repayment capacities could pay off only 73.4 percent of total project construction costs and 66.9 percent of total costs, including the private costs, in 50 years. Only 38 percent of the farmers could pay the average to amortize construction costs and only 4 percent to repay total costs. In order to assure complete amortization of total costs within 50 years, those farmers with below-average repayment capacities, as defined above, would have had to depress their savings-consumption

outlays in order to pay the same average per hectare water fee assessed all Ta-Pu farmers.

In view of the wide range of repayment capacities, some system of discriminatory pricing, based on the marginal value of water to each farmer, would be a more logical and equitable pricing system than the average-price system as prescribed by Taiwan water law and used by all Irrigation Associations. Since average pricing was the law we ruled out, in our analysis, any system of differential or marginal pricing.

Two practical alternatives remain for bridging the gap between cost-amortization requirements and repayment abilities. The two alternatives are: compulsory payment of high fees and subsidization.

Table 51. Annual Installments Needed to Repay Ta-Pu Construction Costs, by Type of Costs and per Hectare

(Annual payments NT$)

Type of costs	Total NT$	5 years	10 years	20 years	30 years	40 years	50 years
Project construction costs	63,980,605	17,748,220	11,324,567	8,567,003	8,157,527	7,939,993	7,703,265
Maintenance and operation	—	714,079	714,079	714,079	714,079	714,079	714,079
Reclamation	5,354,620	1,217,641	608,820	304,410	152,205	76,102	38,051
Total	69,335,225	19,679,940	12,647,466	9,585,492	9,023,811	8,730,174	8,455,395
Average per ha.	44,964	12,763	8,202	6,216	5,852	5,662	5,483

COMPULSORY PAYMENTS OF HIGH WATER FEES

Ta-Pu farmers utilized 40 percent on the average of the incremental income from irrigation to increase their levels of living for two reasons: (1) their pre-irrigation levels of living were below that of other farm families in Taiwan, and (2) the water fee assessed for repayment of the subsidized construction loan allowed such an upward adjustment. The United States Bureau of Reclamation recommends that 30 percent of the increment be allowed for increased living levels (70 percent to be used for repayment purposes) (42).

What effect would reduced living allowances in the Ta-Pu project (by forcing the payment of high water fees) have on the farmers' repayment ability? We show this effect in Table 52. We assumed that at least a 20

percent gain in levels of living is necessary to induce farmers to undertake and repay an irrigation investment.

Table 52. Amounts Available for Repayment, by Varying Living Levels

Living allowances (percent of direct benefits)	Average amount per hectare (NT$)
20	4,880
30	4,271
40	3,667

Comparing these figures with the water fees required to amortize investment costs at 12 percent for 50 years (NT$4,996 for construction costs only and NT$5,483 for construction and private reclamation, maintenance and operation costs Table 51), we find that Ta-Pu farmers could have paid off all of the construction costs in 50 years and about 90 percent of total costs, if living allowances were depressed to 20 percent. One effect of this solution would be to depress the living levels of a majority of farmers and to increase the profits of the minority of large farmers.

The above analysis indicates, however, that theoretically the Ta-Pu construction costs could have been paid for by the farmers without external subsidy if a long-term (50-year) pricing policy had been adopted. If allowances were made for improved price ratios and farming practices, and greater substitution of farmer labor for hired labor to reclaim land and to maintain and operate the irrigation system, even the total costs could have been covered on these terms.

The average water fee need not remain the same for the full life of the project. Prudent financial management would suggest tailoring the water fee more closely to repayment abilities. In earlier years, when reclamation costs were high, the water fee could be lower and gradually increased each year or stepped up every three years or so. A graduated repayment schedule would enable the benefited farmers to retain a greater portion of the earlier benefits for increased consumption levels and coverage of reclamation costs. Allowing farmers, however, to attain higher levels of consumption than could be maintained for the life of the project might result in water-fee defaults later.

An increase in the interest rate, a shorter repayment period, or an increase in living allowances would widen the disparity between cost-amortization requirements and repayment capacities and necessitate the subsidization of the Ta-Pu project.

SUBSIDIZATION

The second alternative, then, would be to subsidize the costs of the project (the one adopted) or the incomes of the repaying farmers.

Subsidization could be justified for several reasons: (1) the 12 percent interest rate, 50-year repayment period, and 20-percent living allowance are unrealistic terms; (2) farmer participation was compulsory; (3) many farmers were economically better off before the project, or relative to others, than after; and (4) the tangible public benefits amounted to 19 percent of total benefits.

A cost subsidy might take a variety of forms but the most common for irrigation projects is a grant of construction funds and/or the lending funds at a below-market rate of interest. The Ta-Pu project was constructed on the basis of a grant-interest rate subsidy. The total grants amounted to 53.5 percent of the final construction costs, which accounted for more than 90 percent of total costs; the remaining loan portion carried a 6 percent per annum interest for a 13-year amortization period.

Financing farm reclamation costs was made the responsibility of the individual farmers and maintenance-operation expenses of the Ta-Pu irrigation system were prorated among all of the farmers in the Chunan Irrigation Association. Some reclamation costs were indirectly subsidized by low-interest loans (Table 34), and Ta-Pu farmers were indirectly subsidized by non-Ta-Pu farmers who paid a higher ordinary fee after the project was constructed, to cover the added maintenance and operation costs, than before.

The original special water fees per hectare (Table 35) began at NT$ 3,086 in 1960 and were scheduled to increase to NT$4,531 in 1971 when the full 1,343 hectares were to be under irrigation. The 1962 revised special water fee schedule called for NT$2,500 and NT 4,000 by 1973. Added to these amortization costs were an average annual reclamation cost of

NT$453 per hectare plus an annual NT$532 per hectare charge for maintenance and operation. The average amount available for meeting these costs was NT$3,667 per hectare, and the median was NT$3,412, which in relation to the per hectare costs given above, would indicate that the subsidies were not only justified but inadequate.

As was suggested earlier, the amounts available for repaying irrigation loans could be made more adequate by utilizing, singly or in combination, the various financial adjustments discussed previously. For example, a much longer period for repaying the Ta-Pu project costs would appear reasonable in view of the long-life of the project and I.D.A.'s 20-year term to farmers for the repayment of the high-yielding, ground-water-pumping loans (cf. p. 61).

In conclusion we should not overlook other alternative solutions. For example, a reduction of costs might have been achieved through better designing, planning and managing of the entire project. Instead, actual costs increased by 40 percent over planned costs. If these measures could not have produced sufficient economies to have justified the project without benefit of an external subsidy, the final solution would have been to postpone construction until the benefit-cost ratios were more favorable and the market rate of interest were lower.

Summary

The restudy of the economic feasibility of the Ta-Pu irrigation project substantiated its feasibility but the benefit-cost ratio was below the 1956 ratio used to justify the project. The discrepancy in ratios was sizeable and can be accounted for by: (1) a 6 percent discount rate used in the original study and a 12-percent rate in the restudy; (2) construction costs 50 percent higher than planned; and (3) benefits lower than anticipated, due chiefly to an underestimation of the amount of double-paddy land farmed before the project was constructed.

A 13-percent rate of return on the irrigation investment was calculated from the farm-economy restudy data. This return justified the 12 percent rate used in the restudy for computing benefits and costs, which is the cut-off point employed by U.S. AID authorities for determining the priority of projects requiring external financing. The average incremental

return on farm capital was only 9.53 percent, however. The low return on farm capital was due to the large increase in farm land values after irrigation water was assured, and because the benefits accrued chiefly to a large number of small farmers.

The total costs, if financed with a 12 percent per annum loan, could have been paid off from the benefits received if farmers were given 50 years to repay and they were willing to reduce their living allowances in the early years from 40–to 20–percent of the added income derived from the Ta-Pu irrigation water. A heavier repayment burden would fall on the large number of small farmers and a lighter burden on the few large farmers, in view ot the wide range in their repayment capacities.

Ta-Pu farmers were granted a government subsidy amounting to 53.5 percent of the construction costs and the loan balance at 6 percent per annum. Subsidization appears to have been justified in view of the compulsory nature of the project, the wide range in farmer benefits, and the 19 percent of total tangible benefits accruing to the public. Whether the subsidy as granted was justified is open to question. Many other alternatives could have been employed in financing the project, which would have reduced the amount of subsidy required, such as a longer repayment period and graduated repayments. If the loan-funds were generated by Taiwan farmers more of the subsidy burden could have been transferred from the government to the benefited farmers.

In view of the final, low benefit-cost ratio, greater consideration should have been given at the outset to cost-reduction economies or to the postponement of the project, until the benefit-cost ratio improved and the market rate of interest was lowered. Other projects could conceivably have returned a greater rate of immediate benefits to the Taiwan economy.

Appendix A

Table A-1. Estimated Production Costs of Selected Crops, and Hogs, per Hectare or Head, 1959.[1]

Items of cost	Sweet potatoes		Peanut		Pineapple		Wheat		Chinese cabbage[2]	
	Amount (NT$)	%	Amount (NT$)	%	Amount (NT$)	%	Amount (NT$)	%	Amount (NT$)	%
Seed or seedling	458.91	9.25	826.78	16.81	1,152.14	11.72	454.24	6.58	473.50	3.76
Fertilizer	1,406.82	28.38	967.24	19.67	2'724.77	27.71	2,246.25	32.51	4,341.00	34.41
Self-supplied	715.36	14.43	649.76	13.21	109.48	1.11	553.21	8.01	2,036.80	16.14
Purchased	691.46	13.95	317.48	6.46	2,615.29	29.60	1,693.04	24.50	2,305.20	18.27
Labor	1,424.20	28.73	1,466.34	29.82	3,933.10	40.00	1,953.14	28.27	4,991.80	39.57
Family	1,151.70	23.23	1,136.36	23.11	1,732.78	17.62	1,423.50	20.61	4,851.30	37.69
Hired	272.50	5.50	329.98	6.71	2,200.32	22.38	529.44	7.66	237.50	1.88
Animal rent	594.32	11.99	385.28	7.83	175.61	1.79	154.89	2.25	370.10	2.93
Family	505.29	10.19	349.47	7.11	59.45	0.61	130.96	1.90	354.70	2.81
Hired	89.03	1.80	35.81	0.72	116.16	1.18	23.93	0.35	15.40	0.12
Materials and others	25.01	0.50	65.91	1.34	280.97	2.86	129.45	1.87	575.50	4.56
Deprec. & repair	189.33	3.82	225.95	4.60	441.43	4.49	245.39	3.55	236.50	1.87
Housing	116.74	2.35	145.36	2.96	317.34	3.23	150.62	2.18	149.20	1.18
Implements	72.59	1.47	80.59	1.64	124.09	1.26	94.77	1.37	87.30	0.69
Taxes and others	325.12	6.56	427.76	8.70	270.88	2.76	476.53	6.90	435.40	3.45
Land interest and rent	533.92	10.77	552.76	11,23	853.47	8.67	1.248.54	18.07	1,191.60	9.45
Total	4,957.63	100	4,918.02	100	9,832.37	100	6,908.43	100	12,615.40	100
Hectares planted in Taiwan	226,486		99,135		8,884		22,841		7,205	

(1) Per year for pineapple and tea, per crop (about three months) for other crops, per head (about 9 months) for hogs.

(2) Data are for 1958.

Table A-1. Continued

Items of cost	Tea leaf		Soybean		Banana		Rice		Items of cost	Hogs	
	Amount (NT$)	%	Amount (NT$)	%	Amount (NT$)	%	Amount (NT$)	%		Amount (NT$)	%
Seed or seedling	78.23	1.28	477.37	9.22	131.48	1.74	148.03	1.94	Pig value	373.14	24.39
Fertilizer	626.55	10.25	1,102.93	21.29	996.13	13.21	1,641.26	21.55	Feed	813.55	53.19
Self supplied	235.51	3.85	339.48	6.55	76.69	1.02	872.82	11.46	Fuel	103.42	6.76
Purchased	391.04	6.40	763.45	14.74	919.44	12.19	768.44	10.09	Labor	169.77	11.10
Labor	3,356.86	54.91	1,289.41	24.89	4,370.77	57.98	2,630.13	34.54	Hog-shelter	31.25	2.04
Family	1,736.76	28.41	987.97	19.07	3,109.79	41.25	1,427.74	18.75	Tools	18.68	1.22
Hired	1,620.10	26.50	301.44	5.82	1,260.98	16.73	1,202.39	15.79	Castration & medicine	19.24	1.26
Animal rent	215.88	3.53	514.89	9.94	12.40	0.16	391.84	5.15	Others	0.56	0.04
Family	174.37	2.85	436.45	8.43	11.16	0.15	281.51	3.70	Total	1,529.61	100.00
Hired	41.51	0.68	78.44	1.51	1.24	0.01	110.33	1.45			
Materials & others	69.03	1.13	303.34	5.86	1,439.76	19.10	105.30	1.38			
Deprec. & repair	165.52	2.70	179.88	3.47	284.48	3.77	168.20	2.21			
Housing	95.06	1.55	121.96	2.35	157.72	2.09	46.75	0.61			
Implements	70.46	1.15	57.92	1.12	126.76	1.68	121.45	1.60			
Taxes and others	182.24	2.98	477.89	9.23	73.07	0.97	230.05	3.02			
Land interest and rent	1.419.42	23.22	834.00	16.10	231.22	3.07	2,300.59	30.21			
Total	6,113.73	100	5,179.71	100	7,539.31	100	7,615.40	100			
Hectares planted in Taiwan	48,442		53,785		12,962		776,050		Numbers stocked in Taiwan	3,263,633	

Sources: *Report on Agricultural Basic Survey in Taiwan, 1960 edition; Report on Economic Investigation of Income and Expenditure in Hog Raising, 1959*, PDAF, March 1960, and *Production Cost of Rice, 1959*, Provincial Food Bureau, 1959.

Table A-2.
Agricultural Investments in the Third Four-year Plan by Types and Sources of Funds, at 1959 Constant Prices.

Sources of funds	Total investment		Irrigation and flood (NT$ mil.)	Crops and livestock (NT$ mil.)	Forestry (NT$ mil.)	Fishery (NT$ mil.)
	Amount (NT$ mil.)	(Percent)				
1961						
Government	370	25.17	96	101	147	26
Private	629	42.79	48	402	45	134
U. S. Aid	471	32.04	203	101	93	74
Total	1,470	100.00	347	604	285	234
1962						
Government	425	23.48	144	107	148	26
Private	761	42.04	107	473	47	134
U. S. Aid	624	34.48	346	118	87	73
Total	1,810	100.00	597	698	282	233
1963						
Government	439	20.22	151	116	146	26
Private	941	43.34	196	555	49	141
U. S. Aid	791	36.44	511	125	78	77
Total	2,171	100.00	858	796	273	244
1964						
Government	458	17.79	161	122	145	30
Private	1,181	45.86	367	596	51	167
U. S. Aid	936	36.35	613	131	103	89
Total	2,575	100.00	1,141	849	299	286

Source: *The Agricultural Program Under Taiwan's Third Four-year Plan,* Agricultural Planning and Coordination Committee, Ministry of Economic Affairs, Republic of China, December 1961, p. 25. For a detailed breakdown of planned capital expenditures by activities see pp. 27-29.

Appendix B

Table B-1. Investment and Operational Outlays for Irrigation, by Government and Irrigation Associations, in Current and 1935-37 Constant Prices, Before Retrocession, 1901-1945.

Calendar year	At current price					At 1935-37 constant OT$ price				
	Investments on irrigation			Operational outlays	Total investment and operational outlays	Investments on irrigation	Operational outlays	Total investment and operational outlays	Total paddy field (ha.)	Operational outlays per hectare of paddy field
	Government	Irrigation associations	Total							
1901	6,400	—	6,400	100,000	106,400	12,800	200,000	**212,800**	206,753	0.97
02	35,690	—	35,690	150,000	185,690	71,380	300,000	**371,380**	245,388	1.22
03	54,710	—	54,710	170,303	225,013	109,420	340,606	**450,026**	278,190	1.22
04	67,520	—	67,520	271,603	339,123	135,040	543,206	**678,246**	303,196	1.79
05	14,360	—	14,360	266,465	280,825	28,720	532,930	**561,650**	304,907	1.75
06	36,554	120,000	156,554	317,034	473,588	313,108	634,068	**947,176**	309,615	2.05
07	236,437	15,000	251,437	616,919	868,356	502,874	1,233,838	**1,736,712**	318,658	3.87
08	137,790	70,000	207,790	863,404	1,071,194	415,580	1,726,808	**2,142,388**	322,800	5.35
09	1,323,948	35,900	1,359,848	961,601	2,321,449	2,719,696	1,923,202	**4,642,898**	327,620	5.87
10	960,577	—	960,577	991,212	1,951,789	1,921,154	1,982,424	**3,903,578**	332,372	5.96
11	780,811	—	780,811	1,105,979	1,886,790	1,498,102	2,121,986	**3,620,088**	334,928	6.34
12	854,714	—	854,714	1,258,374	2,113,088	1,417,906	2,087,548	**3,505,454**	335,955	6.21
13	968,626	—	968,626	1,047,849	2,016,475	1,575,770	1,704,651	**3,280,421**	337,610	5.05
14	—	—	—	1,167,085	1,167,085	—	1,980,460	**1,980,460**	339,594	5.83
15	—	123,000	123,000	1,437,982	1,560,982	197,463	2,308,528	**2,505,991**	343,087	6.73
16	413,732	—	413,732	1,353,562	1,767,294	567,145	1,855,465	**2,422,610**	347,879	5.33
17	760,813	67,200	828,013	1,535,720	2,363,733	921,961	1,709,965	**2,631,926**	320,528	5.33
18	696,070	58,000	754,070	1,555,399	2,309,469	653,553	1,348,067	**2,001,620**	341,479	3.95
19	849,889	467,500	1,317,389	1,811,000	3,128,389	1,004,337	1,380,651	**2,384,988**	345,101	4.00
20	2,375,211	82,500	2,457,711	3,870,940	6,328,651	1,620,326	2,552,044	**4,172,370**	367,177	6.95
21	3,242,107	616,350	3,858,457	8,676,605	12,535,062	3,277,100	7,369,292	**10,646,392**	364,148	20.24
22	3,197,341	287,912	3,485,253	8,549,216	12,034,469	2,952,854	7,243,257	**10,196,111**	365,002	19.84
23	3,028,419	10,056,000	13,084,419	8,549,668	21,634,087	11,492,682	7,509,590	**19,002,272**	365,434	20.55
24	2,031,165	2,948,685	4,979,850	7,443,197	12,423,047	4,316,043	6,451,029	**10,767,072**	368,642	17.50
25	2,496,684	3,912,442	6,409,126	11,254,416	17,663,542	5,574,607	9,789,003	**15,363,610**	373,629	26.20
26	1,400,000	6,544,775	7,944,775	15,175,524	23,120,299	7,264,126	13,875,399	**21,139,525**	382,093	36.31
27	3,000,000	5,452,900	8,452,900	15,983,388	24,436,288	7,929,550	14,993,797	**22,923,347**	387,144	38.73
28	6,015,045	16,322,617	22,337,662	28,075,301	50,412,963	21,636,635	27,194,209	**48,830,844**	391,714	69.42
29	2,544,962	7,312,917	9,857,879	20,146,626	30,004,505	9,840,167	20,110,427	**29,950,594**	393,817	51.07
30	3,607,187	3,076,200	6,683,387	15,098,238	21,781,625	7,481,683	16,901,643	**24,383,326**	396,279	42.65

Table B-1. (Continued)

Calendar year	At current price					At 1935-37 constant OT$ price				
	Investments on irrigation			Operational outlays	Total investment and operational outlays	Investments on irrigation	Operational outlays	Total investment and operational outlays	Total paddy field (ha.)	Operational outlays per hectare of paddy field
	Government	Irrigation associations	Total							
1931	663,822	3,861,390	4,525,212	12,316,924	16,842,136	5,638,191	15,346,280	20,984,471	398,709	38.49
32	580,824	1,346,523	1,927,347	7,564,089	9,491,436	2,353,006	9,234,634	11,587,640	426,246	21.67
33	630,212	1,451,007	2,081,219	8,563,836	10,645,055	2,375,007	9,772,722	12,147,729	436,934	22.37
34	1,029,552	2,130,638	3,160,190	8,685,415	11,845,605	3,464,361	9,521,393	12,985,754	448,990	21.21
35	977,373	2,779,789	3,757,162	9,889,207	13,646,369	4,048,230	10,655,325	14,703,555	478,689	22.26
36	—	434,640	434,640	8,198,563	8,633,203	452,797	8,541,060	8,993,857	517,771	16.50
37	—	347,836	347,836	8,567,213	8,915,049	312,802	7,704,328	8,017,130	528,061	14.59
38	80,000	391,657	471,657	9,025,260	9,496,917	355,753	6,807,407	7,163,160	526,829	12.92
39	25,000	2,499,157	2,524,157	11,202,599	13,726,756	1,657,903	7,358,029	9,015,932	530,111	13.88
40	4,206,445	2,763,806	6,970,251	14,842,746	21,812,997	4,051,765	8,627,999	12,679,764	529,621	16.29
41	7,434,302	2,492,430	9,926,732	16,178,745	26,105,477	5,304,158	8,644,801	13,948,959	527,992	16.37
42	5,873,372	3,507,114	9,380,486	17,365,615	26,746,101	5,070,807	9,387,326	14,458,133	524,544	17.90
43	5,728,652	2,973,115	8,701,767	21,887,346	30,589,113	2,753,985	6,927,033	9,681,018	519,871	13.32
44	9,488,337	3,131,220	12,619,557	28,825,805	41,445,362	2,381,228	5,439,242	7,820,470	501,425	10.85
45	6,694,895	2,939,013	9,633,908	35,060,833	44,694,741	354,030	1,288,428	1,642,458	504,710	2.53
Summary by periods										
1901-10	2,873,986	240,900	3,114,886	4,708,541	7,823,427	6,229,772	9,417,082	15,646,854	2,949,499	3.19
1911-20	7,699,866	798,200	8,498,066	16,143,890	24,641,956	9,456,563	19,049,365	28,505,928	3,413,338	5.58
1921-30	30,562,910	56,530,798	87,093,708	138,952,179	226,045,887	81,765,447	131,437,646	213,203,093	3,787,902	34.70
1931-40	8,193,228	18,006,443	26,199,671	98,855,852	125,055,523	24,709,815	93,569,177	118,278,992	4,821,961	19.40
1941-45	35,219,558	15,042,892	50,262,450	119,318,344	169,580,794	15,864,208	31,686,830	47,551,038	2,578,542	12.29

Source: Office of Economic Research, Bank of Taiwan, *Irrigation Problems of Taiwan*, Economic Series No. 4, July 1950 (in Chinese)

Table B-2. Investment and Operational Outlays for Irrigation, by Government and Irrigation Associations, in Current and 1935–37 Constant Prices, After Retrocession, 1946–60[1]

Fiscal year	At current price					At 1935-37 constant price				
	Investment on irrigation			Operational expenditure[2]	Total expenditure	Investment on irrigation	Operational expenditure	Total expenditure	Total paddy field (ha.)	Operational expenditure per ha. of paddy field
	Government subsidies	Irrigation associations	Total							
1946	—	27,471,278	27,471,278	195,768,105	223,239,383	254,053	1,810,457	2,064,510	507,636	3.57
47	—	234,698,888	234,698,888	1,166,559,115	1,401,258,003	450,803	2,240,693	2,691,496	516,379	4.34
48	—	1,578,423,372	1,578,423,372	10,999,540,269	12,577,963,641	364,321	2,538,837	2,903,158	526,384	4.82
49	—	4,870,045	4,870,045	14,226,508	19,096,553	1,956,627	5,715,752	7,672,379	528,097	10.82
50	449,694	9,349,861	9,799,555	61,557,463	71,357,018	970,839	6,098,482	7,069,321	530,236	11.50
51	14,929,051	11,117,875	26,046,926	76,430,265	102,477,191	1,554,641	4,561,830	6,116,471	533,803	8.55
52	24,040,907	15,483,554	39,524,461	99,601,683	139,126,144	1,915,975	4,828,260	6,744,235	533,643	9.05
53	26,355,915	15,030,054	41,385,969	111,231,049	152,617,018	1,844,574	4,957,572	6,802,146	533,316	9.30
54	27,494,832	9,197,593	36,692,425	144,392,707	181,085,132	1,597,566	6,286,773	7,884,339	532,565	11.80
55	37,838,791	15,067,264	52,906,055	100,934,277	153,840,332	2,019,061	3,851,968	5,871,029	532,688	7.23
56	41,117,345	54,044,643	95,161,988	129,957,445	225,119,433	3,222,280	4,400,489	7,622,769	533,113	8.25
57	20,734,446	36,159,830	56,894,276	147,770,376	204,664,652	1,796,728	4,666,605	6,463,333	533,144	8.75
58	56,754,989	84,576,562	141,331,551	167,912,845	309,244,396	4,402,002	5,229,920	9,631,922	533,674	9.80
60[3]	26,001,877	90,771,536	116,773,413	378,252,283	495,025,696	2,815,086	9,118,622	11,933,708	525,580	17.35
1946–50						3,996,643	18,404,221	22,400,864	2,608,732	7.05
1951–60	275,268,153	331,448,911	606,717,064	1,356,482,930	1,963,199,994	21,167,913	47,902,039	69,069,952	4,791,526	10.00

[1] The government data from 1945 through 1956 are crude estimates from budgets, some, perhaps as much as one-half, of the government subsidies were used for repair and maintenance rather than for new investments. The data for 1957 through 1960 are taken from receipt and disbursement records compiled by the Provincial Water Conservancy Bureau from the records of the 26 Irrigation Associations.

[2] Includes administration, maintenance, repair and repayment of loans.

[3] **Changed identification of fiscal years from beginning of the period (July 1) to end of period (June 30). 1960 data are for the July 1, 1959 to June 30, 1960 period.**

[4] Includes NT$ 40,295,000 in provincial government budget and NT$ 50,613,212 in JCRR budget for rehabilitation of damage caused by the Aug. 7, 1959 flood.

Sources: "Financial Status of the Irrigation Association" Provincial Federation of Irrigation Association, 1952.

Appendix C

Table C–1. Major Projects of Irrigation Development Under Construction or Planning[1]

Name of project[2]	Location (Hsiens)	Estimated increase of new irrigation area[3]		Estimated improvement of existing irrigation area		Estimated annual increase of rice in m/t	Estimated project cost or allocation to irrigation in NT$	Principal purposes of development
		Reported in crop ha.	Reported in ha.	Reported in crop ha.	Reported in ha.			
1. Paiho reservoir	Tainan		2,721		2,068	8,400	164,601,000	Irrigation, water supply, flood control, recreation.
2. Houlung reservoir	Miaoli		1,682		316	7,964	148,000,000	Mainly for irrigation.
3. Tsengwen reservoir	Chiayi		7,301		80,468	100,000	1,937,480,000	Irrigation, water supply, power generation.
4. Tachia reservoir	Taichung		13,515		20,562	56,000	1,197,264,000	Irrigation, flood control, power generation.
5. Shihmen reservoir	Taoyuan		15,096		37,513	74,000	1,707,595,000	Irrigation, flood control, water supply, power generation, recreation.
6. Kaoping basin development	Kaohsiung and Pingtung				63,151	No estimate	No estimate	Mainly for irrigation.
7. Choshui basin development	Nantou, Changhwa & Yunlin	62,765				No estimate	No estimate	Irrigation, flood control, power generation, water supply.
8. Peinan basin development	Taitung		1,831		1,812	No estimate	No estimate	Irrigation, power generation, flood control.
9. Canal lining	Chiayi and Tainan				123,400	28,000	300,000,000	Water saving.
10. Rotational irrigation	Island-wide		10,822		48,527	60,000	376,480,000	Irrigation, improvement.
11. Ground water development	Island-wide	78,545		140,538		246,378	788,100,000	Supplementary irrigation.

[1] As of May 8, 1962.

[2] See footnotes for status description of each project.

[3] Acreages should not be added to obtain totals; some are irrigated occasionally. Crop hectares refer to two crops of rice per year per hectare; other hectares reported may produce two crops of rice per hectare, too.

Table C-1 (Continued)

Name of projects	Status description	Sources of data
1. Paiho reservoir	Construction has been underway with TPG fund since 1961.	Definite Plan Report by PWCB, November 1961.
2. Houlung reservoir	Project planning has been undertaken by PWCB with JCRR financial assistance since FY 1955.	Summary of Houlung Reservoir by PWCB, April 1962.
3. Tsengwen reservoir	Project planning has been undertaken by PWCB with JCRR financial support.	Preliminary Planning Report by PWCB, January 1962.
4. Tachia reservoir	Taichien dam construction is under preparation. Irrigation work will be started after completion of planning now underway by PWCB. Sources and method of financing of construction has not been agreed upon.	Definite Plan Report by WRPC, October 1959.
5. Shihmen reservoir	Reservoir and main canal are under construction, and will be completed in 1963. Irrigation distribution systems started in 1961.	Economic Study of Shihmen Multipurpose Project, by SDC, Sept. 1960.
6. Kaoping basin development	Planning of Erhjen diversion (for 18,000 ha.) will be completed by the end of 1962 by PWCB. Planning studies of basin started in 1961 by WRPC.	Preliminary Planning Report by 1st Planning Team, PWCB, April 1962.
7. Choshui basin development	Planning is undertaken by WRPC. A few projects will be finalized in 1962. This basin has been under planning since 1955.	Preliminary Proposal of Choshui Basin Irrigation, by WRPC, Jan. 1962.
8. Peinan basin development	Preliminary planning was undertaken by WRPC.	An Outline of Peinan Multipurpose Project, by WRPC, Dec. 1961.
9. Canal lining	The project covering lining of 1,024 km. over the Chianan Irrigation Association's jurisdiction has been implemented since 1960 with TPG and JCRR funds.	Project Plan by PWCB, June 1959.
10. Rotational irrigation	Program is underway but departed somewhat from the 10-year plan because of funding problems.	10-Year Plan by RIPC.
11. Ground water development	Entire program covers drilling of 1,600 deep wells, of which 302 wells were completed (252 under JCRR financing and 50 under TPG financing). Another 765 wells program with subsidy of NT$ 183,200,000 from TPG, and loans of US$ 3,700,000 from IDA and NT$ 126,800,000 from AID is underway, and scheduled to be completed by the end of FY 1964.	A Brief Report by GWDB, June, 1960.

Abbreviations: PWCB—Provincial Water Conservancy Bureau. TPG—Taiwan Provincial Government
WRPC—Water Resources Planning Commission. JCRR—Joint Commission on Rural Reconstruction
SDC—Shehmen Dam Commission. IDA—International Development Association
RIPC—Rotational Irrigation Planning Commission. AID—Agency for International Development

Sources: This table was compiled from data submitted by concerned agencies, by the Irrigation and Engineering Division of JCRR, May 1962.

Appendix D

Table D-1. Comparison of Rice and Fertilizer Indices, 1901–1950.

1938=100

Period	Total ha. planted to rice	Total rice produced	Farm rice price	Rice production per crop. hectare	Fertilizer applied to rice	Irrigated hectares
1901	56.5	31.2	23.5	55.3	28.4	
02	55.2	28.7	29.6	52.1	30.3	
03	63.1	37.5	34.1	59.3	30.2	
04	69.6	42.4	23.7	60.9	38.6	
05	71.5	44.4	27.4	62.0	39.0	
06	73.3	40.4	33.4	55.1	40.2	
07	75.4	46.0	45.3	61.0	44.0	
08	76.6	47.4	33.9	62.0	43.7	
09	76.6	47.2	30.5	61.6	44.6	
10	73.0	42.7	35.1	58.5	45.6	
11	76.6	45.7	46.7	59.8	46.7	
12	76.9	41.2	57.8	53.6	47.1	
13	79.0	52.2	52.6	66.1	46.8	
14	79.9	46.9	39.7	58.7	47.9	
15	78.5	48.7	32.1	62.1	48.7	
16	75.4	47.4	37.8	62.8	49.6	
17	74.5	49.2	55.3	66.1	52.6	
18	77.3	47.2	83.1	61.1	55.9	
19	79.5	50.2	110.8	63.1	60.6	
20	80.0	49.3	92.9	61.7	61.3	
21	79.2	50.7	73.1	64.0	62.5	
22	81.8	55.5	61.1	67.8	63.3	11.3
23	81.2	49.6	72.7	61.1	65.8	12.4
24	85.0	61.9	88.8	72.8	66.9	16.3
25	88.1	65.6	104.0	74.5	70.4	21.8
26	90.7	63.3	95.7	69.8	74.5	26.3
27	93.5	70.3	78.2	75.2	76.2	27.3

Table D-1. (Continued)

Period	Total ha. planted to rice	Total rice produced	Farm rice price	Rice production per crop hectare	Fertilizer applied to rice	Irrigated hectares
1928	93.5	69.2	81.4	74.0	78.0	31.7
29	90.8	66.0	81.4	72.7	88.1	32.2
30	98.2	75.1	60.0	76.4	88.7	35.4
31	101.3	76.2	47.0	75.2	90.3	36.9
32	106.2	91.2	85.3	85.8	90.4	45.0
33	108.0	85.2	61.9	78.9	91.9	53.0
34	106.7	92.6	75.0	86.8	92.7	65.0
35	108.5	92.9	89.3	85.6	93.6	75.0
36	109.0	97.4	92.4	89.4	97.6	90.0
37	105.2	94.1	93.3	89.5	100.1	95.0
38	100.0	100.0	100.0	100.0	100.0	100.0
39	100.1	93.2	109.0	93.1	100.8	90.2
40	102.1	80.5	111.5	78.9	101.2	76.3
41	103.4	85.5		82.6	102.4	69.3
42	98.6	83.5		84.7	101.0	58.3
43	97.5	80.3		82.3	100.6	58.6
44	96.0	76.2		79.3	99.2	19.8
45	80.3	45.6		56.8	92.8	0.5
46	90.2	63.7		70.7	93.5	19.1
47	108.3	71.2		65.7	98.6	22.4
48	114.8	76.2		66.4	102.0	25.9
49	119.6	86.6		72.4	103.6	59.5
50	123.2	101.4		82.3	105.0	71.9

Sources: Rice production and plantings from *Taiwan Food Statistics Book, 1961,* Taiwan Food Bureau; fertilizer from *Taiwan Food Statistics Book* and *Taiwan Agricultural Yearbook;* farm rice price from *Taiwan Agricultural Yearbook;* irrigated hectares from Rural Economics Division, JCRR.

Table D–2. Comparison of Rice and Fertilizer Indices 1949–1960.

1957=100

Period	Total ha. planted to rice	Total rice produced	Rice production per crop hectare	Farm rice price	Fertilizer applied to rice	Irrigated hectares
1949	95.5	66.0	69.2	17.4	20.5	97.8
50	98.3	77.3	78.6	29.8	47.1	99.2
51	100.7	80.7	80.2	34.3	56.9	99.3
52	100.3	85.4	85.1	63.1	73.6	98.0
53	99.4	89.3	89.8	94.2	76.9	99.4
54	99.2	92.2	93.0	70.3	93.5	97.8
55	95.9	87.8	91.6	91.1	89.8	97.1
56	100.1	97.3	97.3	90.3	99.6	99.7
57	100.0	100.0	100.0	100.0	100.0	100.0
58	99.4	103.0	103.7	101.2	101.7	100.3
59	99.1	100.9	101.9	109.5	101.3	99.4
60	97.9	104.0	106.3	165.9	102.7	104.3

Sources: Same as Appendix D, Table D-1.

Table D–3. Quantity of Fertilizer Used, by Farmed Hectares 1930–1960

Period	Quantity of Fertilizer Used (m/t)	Hectares Farmed (ha.)	Quantity of Fertilizer Used per Hectare (kg/ha)
1930	294,268	1,012,089	291
31	271,746	1,028,687	265
32	290,050	1,078,635	269
33	319,477	1,074,098	297
34	396,731	1,083,074	366
35	422,715	1,130,524	374
36	492,697	1,144,489	430
37	508,071	1,123,330	452
38	518,166	1,103,956	469
39	479,864	1,146,837	418
40	419,110	1,173,990	357
41	388,000	1,183,720	328
42	309,303	1,154,823	268
43	290,183	1,127,829	257
44	154,459	1,119,488	138

Table D-3. (Continued)

Period	Quantity of Fertilizer Used (m/t)	Hectares Farmed (ha.)	Quantity of Fertilizer Used per Hectare (kg/ha)
1945	25,929	904,175	28
46	30,639	980,727	31
47	124,593	1,193,583	104
48	128,770	1,345,785	96
49	153,270	1,437,929	107
50	289,529	1,483,516	195
51	368,511	1,483,007	248
52	470,439	1,506,428	312
53	489,924	1,505,851	325
54	575,376	1,519,006	379
55	574,151	1,495,161	384
56	641,047	1,537,152	417
57	659,575	1,563,038	422
58	683,961	1,590,063	430
59	684,153	1,593,522	429
60	608,215	1,595,469	381

Table D-4. Value of Fertilizer Applied to Rice per Hectare 1951-1960

Period	Quantity of brown rice to be paid for fertilizer applied (kg/ha/year)	Farm price of brown rice (NT$/M. T.)	Value of fertilizer per ha. per year (NT$)
1951	524	1,098	575.35
1952	618	1,835	1,134.03
1953	620	2,871	1,780.02
1954	752	2,481	1,865.71
1955	778	2,595	2,018.91
1956	810	2,860	2,316.60
1957	828	3,074	2,545.27
1958	856	3,212	2,749.47
1959	854	3,382	2,888.23
1960	862	5,027	4,333.27

Sources:

Quantity: Taiwan Provincial Food Bureau, *Food Production and Activities of the Taiwan Provincial Food Bureau,* 1962, p. 27; Price: JCRR, *Rice Review,* No. 40, April 15, 1962, p. 3.

Appendix E

Table E–1. Irrigation Associations' Indebtedness, by Associations, June 30, 1960[1]

Irrigation associations	Current liabilities				Fixed liabilities			Total liabilities
	Sub-total	Short-term borrowings	Guarantee deposits[2] received	Others[3]	Sub-total	Long-term borrowing	Special borrowings	
Yilan	1,910,871.31	—	—	1,910,871.31	575,250.75	—	575,250.75	2,486,122.06
Keelung	1,024,205.93	—	—	1,024,205.93	359,875.17	359,875.17	—	1,384,081.10
Tamsui	1,352,434.36	222,114.20	—	1,130,320.16	699,250.00	699,250.00	—	2,051,684.36
Chihsing	1,459,378.48	720,000.00	24,428.14	714,950.34	160,000.00	—	160,000.00	1,619,378.48
Hsinhai	1,025,431.01	750,000.00	80.00	275,351.01	75,522.30	—	75,522.30	1,100,953.31
Liukong	7,792,505.80	—	600.00	7,791,905.80	—	—	—	7,792,505.80
Taoyuan	1,732,802.57	—	3,000.00	1,729,802.57	8,249,629.99	1,474,000.00	6,775,629.99	9,982,432.56
Chungli	696,107.66	170,000.00	—	526,107.66	58,072.80	—	58,072.80	754,180.46
Hsinchu	808,334.82	246,759.61	—	561,575.21	236,281.29	—	236,281.29	1,044,616.11
Chunan	608,210.07	50,000.00	—	558,210.07	28,168,993.17	7,134,000.00	21,034,993.17	28,777,203.24
Miaoli	1,011,041.62	601,250.00	—	409,791.62	2,317,916.17	200,000.00	2,117,916.17	3,328,957.79
Wanli	629,624.87	394,410.30	—	235,214.57	819,779.49	30,845.00	788,934.49	1,449,404.36
Dachia	226,037.61	—	800.00	225,237.61	2,017,119.26	—	2,017,119.26	2,243,156.87
Houli	90,941.40	—	—	90,941.40	311,000.00	311,000.00	—	401,941.40
Fonzon	8,966,406.00	1,300,000.00	11,192.00	7,655,214.00	5,349,854.60	—	5,349,854.60	14,316,260.60
Nantou	371,946.44	—	—	371,946.44	3,801,794.53	2,399,669.50	1,402,125.03	4,173,740.97
Nunkao	1,342,526.63	—	—	1,342,526.63	3,737,033.26	1,606,000.00	2,131,033.26	5,079,559.89
Changhwa	55,383,832.62	9,596,331.77	45,000.00	45,742,500.85	47,326,532.31	23,697,042.58	23,629,489.73	102,710,364.93
Chushan	208,328.90	100,000.00	—	108,328.90	1,014,459.47	380,000.00	634,459.47	1,222,788.37
Touliu	7,293,871.67	—	—	7,293,871.67	32,513,898.95	—	32,513,898.95	39,807,770.62
Chianan	13,365,767.83	5,000,000.00	179,188.40	8,186,579.43	95,755,318.27	46,007,843.95	49,747,474.32	109,121,086.10
Kaohsiung	8,810,050.77	6,996,095.90	—	1,813,954.87	5,853,958.65	1,000,000.00	4,853,958.65	14,664,009.42
Pingtung	12,477,050.79	4,341,052.96	—	8,135,997.83	15,139,940.58	7,178,373.01	7,961,567.57	27,616,991.37
Taitung	3,912,734.54	500,000.00	5,962.00	3,406,772.54	—	—	—	3,912,734.54
Hualien	5,383,859.45	2,258,283.60	19,000.00	3,106,575.85	6,594,688.50	2,947,385.50	3,647,303.00	11,978,547.95
Hsinkang	155,211.60	50,000.00	—	105,211.60	—	—	—	155,211.60
Total	138,039,514.75	33,296,298.34	289,250.54	104,453,965.87	261,136,169.51	95,425,284.71	165,710,884.80	399,175,684.26

(1) End of fiscal year.

(2) Performance deposits from construction contractors.

(3) Mostly notes payable and prereceived collections and temporary credits.

Source: Provincial Water Conservancy Bureau

Appendix F

Table F–1. Total Construction Costs of the Ta-Pu Project, 1956–1960

Unit: NT$

	Construction cost of the reservoir	Related project costs	Labor	Materials	Right-of-way and compensation for damages	Administrative costs	Total
1956	—	1,490,201	856,500	230,472	—	—	2,577,173
1957	9,272,690	638,846	298,012	213,985	—	980,454	11,403,987
1958	1,202,820	—	5,531,831	2,142,842	—	464,000	9,341,493
1959	14,463,529	1,065,908	2,790,801	1,331,223	—	1,067,024	20,718,485
1960	—	550,956	6,235,059	2,079,834	8,164,362	572,003	17,602,214
Total	24,939,039	3,745,911	15,712,203	5,998,356	8,164,362	3,083,481	61,643,352

Source: "The Farm-Economy Survey in the Ta-Pu Area," Joint Commission on Rural Reconstruction and Provincial Water Conservancy Bureau 1961.

Table F–2. The Amount and Cost of Reclamation in the Ta-Pu Area After Irrigation, by Survey District, 1961

No. on the survey district	Average farm size (1) ha.	Average reclaimed area per farm (2) ha.	Possible average area to be reclaimed per farm ha.	Average investment on reclamation per farm NT$ (3)	Average investment on reclamation per farm per ha. NT$ 3/1	Total area in the survey district ha.
1	1.79	0.41	—	3,375.00	1,885.00	74.16
2	1.35	0.17	0.20	2,278.00	1,687.00	378.03
3	1.68	0.27	0.15	4,332.00	2,578.00	227.14
4	1.33	0.31	0.20	4,019.00	3,022.00	317.29
5	1.97	0.01	0.04	421.00	214.00	203.48
6	2.77	0.14	0.25	3,000.00	1,083.00	135.64
7	0.97	0.04	0.24	406.00	419.00	248.82
Total	1.62	0.18	0.14	2,615.00	1,614.00	1,584.56

Source: "The Farm-Economy Survey in the Ta-Pu Area," JCRR and PWCB, 1961.

Table F-3. Distribution of Sample Farm Households by Survey Districts, 1961

Survey districts	Irrigation districts	Total farm area (1) ha.	Farm households (2) No.	Combined percentage of (1) & (2) (percent)	Samples allocated[1]
I	(1, 2,)	74.16	69	4.12	5
II	(3, 4, 5, 6, 18, 19,)	378.03	127	14.87	19
III	(7, 8. 9, 10,)	227.14	247	16.61	22
IV	(11, 12, 24, 25, 26, 27,)	317.29	395	25.00	32
V	(14, 15, 16, 17,)	203.48	250	14.24	19
VI	(20, 21, 22,)	135.64	179	10.25	14
VII	(13, 23, 28, 29, 30,)	248.82	208	14.64	19
Total	—	1,584.56	1,475	100.00	130

[1] The 130 sample farm households were selected from the seven survey districts through the method of stratified random sampling.

Note: To obtain the accurate total farm area and total number of farm households in the irrigated area, a cadastral card was prepared for each piece of land. Based on these cards (6,445 of them), the total farm area and farm households in each survey district were determined. Sample farm households were selected from the cadaster in each district. Establishment of the cadastral system for sample selection, as is noted elsewhere, helped us to make a good estimate of total benefits in the irrigation area.

The following items are indicated on a cadastral card: name of farm operator, address, no. on land section, irrigation district, no. on land, land area, land classification, land grade, land price, crop pattern, and crop yield.

Table F-4. Estimated Annual Stream of Net Farm Earning Accruing During the Economic Life of the Ta-Pu Project, 1961-2010

Period of analysis T	Starting date	Farm area ha.	Irrigable area ha.	Crop yields (kg.)				Crop area (ha.)					Receipts[1] from crop production	Receipts from livestock
				Rice	Sweet potato	peanut	Vege-tables	Rice	Sweet potato	Peanut	Vege-tables	Total	NT$	,NT$
0	1959	1,585	758	2,916	6,941	1.092	3,233	1,761	1,130	319	65	3,279	24,212,161	9,494,564
1	1961	1,664	1,340	3,105	7,043	1,190	4,889	2,569	497	190	59	3,315	35,759,747	7,484,815
2	1962	1,664	1,400	3,200	8,000	1,190	6,000	2,800	450	100	24	3,374	35,389,200	8,501,849
3	1963	1,664	1,480	3,300	8,500	1,190	7,500	2,900	450	100	30	3,480	37,794,000	9,033,215
4	1964	1,664	1,520	3,400	9,000	1,190	8,000	2,900	450	100	100	3,550	39,442,000	9,564,580
5	1965	1,664	1,540	3,500	9,500	1,190	8,500	2,900	450	100	225	3,675	41,520,000	10,095,945
6	1966	1,664	1,540	3,500	9,500	1,190	8,500	2,900	450	100	225	3,675	41,520,000	10,095,945
7	1967	1,664	1,540	3,500	9,500	1,190	8,500	2,900	450	100	225	3,675	41,520,000	10,095,945
8	1968	1,664	1,540	3,500	9,500	1,190	8,500	2,900	450	100	225	3,675	41,520,000	10,095,945
9	1969	1,664	1,540	3,500	9,500	1,190	8,500	2,900	450	100	225	3,675	41,520,000	10,095,945
10	1970	1,664	1,540	3,500	9,500	1,190	8,500	2,900	450	100	225	3,675	41,520,000	10,095,945
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
20	1980	1,664	1,540	3,500	9,500	1,190	8,500	2,900	450	100	225	3,675	41,520,000	10,095,945
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
30	1990	1,664	1,540	3,500	9,500	1,190	8,500	2,900	450	100	225	3,675	41,520,000	10,095,945
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
40	3000	1,664	1,540	3,500	9,500	1,190	8,500	2,900	450	100	225	3,675	41,520,000	10,095,945
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
50	2010	1,664	1,540	3,500	9,500	1,190	8,500	2,900	450	100	225	3,675	41,520,000	10,095,945
Accumulation (1961-2010)													2,058,304,947	498,997,929

[1] Farm prices in 1960 were NT$4.00 per kg. of rice, NT$0.80 per kg of sweet-potato, NT$6.00 per kg. of peanut, and NT$0.80 per kg. of vegetables. Expected long-term prices relative to 1960 prices are assumed to be -10% for rice, -20% for sweet-potato, and constant for peanut & vegetables.

Table F-5. Estimated Annual Stream of Indirect Benefits Accruing During the Economic Life of the Ta-Pu Project, 1961–2010

Unit: NT$

Period of analysis	Year	Sale of farm products				Benefits of Provincial Food Bureau			Fishing benefits	Total indirect benefits	Present value of indirect benefits discounted to 1960 at 12 percent per annum
		Crops	Livestock	Sub-total	Additional benefits	Collection of paddy	Paddy-fertilizer exchange	Additional benefits			
0	1959	11,746,252	8,251,206	19,997,458	—	1,258,663	3,511,379	—	—	—	—
1	1961	17,642,561	6,165,600	23,808,161	228,642	1,908,667	5,984,531	714,363	—	943,005	842,009
2	1962	17,459,747	7,003,379	24,463,126	267,940	2,863,000	6,091,038	1,023,030	—	1,290,970	1,029,161
3	1963	18,646,188	7,441,091	26,087,279	365,389	2,863,000	6,282,400	1,063,216	681,120	2,109,725	1,501,702
4	1964	19,459,251	7,878,802	27,338,053	440,436	2,863,000	6,408,770	1,089,754	681,120	2,211,310	1,405,288
5	1965	20,484,461	8,316,512	28,800,973	528,211	3,817,334	6,724,697	1,442,399	681,120	2,651,730	1,504,592
6	1966	20,484,461	8,316,512	28,800,973	528,211	3,817,334	6,724,697	1,442,399	681,120	2,651,730	1,343,366
7	1967	20,484,461	8,316,512	28,800,973	528,211	3,817,334	6,724,697	1,442,399	681,120	2,651,730	1,199,377
8	1968	20,484,461	8,316,512	28,800,973	528,211	3,817,334	6,724,697	1,442,399	681,120	2,651,730	1,071,034
9	1969	20,484,461	8,316,512	28,800,973	528,211	3,817,334	6,724,697	1,442,399	681,120	2,651,730	956,214
10	1970	20,484,461	8,316,512	28,800,973	528,211	3,817,334	6,724,697	1,442,399	681,120	2,651,730	853,857
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
20	1980	20,484,461	8,316,512	28,800,973	528,211	3,817,334	6,724,697	1,442,399	681,120	2,651,730	274,984
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
30	1990	20,484,461	8,316,512	28,800,973	528,211	3,817,334	6,724,697	1,442,399	681,120	2,651,730	88,568
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
40	2000	20,484,461	8,316,512	28,800,973	528,211	3,317,334	6,724,697	1,442,399	681,120	2,651,730	28,373
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
50	2010	20,484,461	8,316,512	28,800,973	528,211	3,817,334	6,724,697	1,442,399	681,120	2,651,730	9,281
Accumulation (1961–2010)		1,015,492,953	411,048,424	1,426,541,377	25,600,113	186,095,031	334,102,801	70,240,717	32,693,760	128,534,590	18,744,821

Table F-4. (Continued)

Other receipts NT$	Value increase NT$	Total farm family earnings (1) NT$	Production expenses NT$	Depreciation NT$	Hired labor expenses NT$	Interest on investment NT$	Livestock purchase NT$	Total expenses (2) NT$	Net farm earning (1)-(2) NT$
12,228,764	326,800	46,262,289	12,226,424	1,130,722	1,874,282	1,249,478	1,498,547	17,979,453	28,282,836
12,683,110	1,288,266	57,215,938	16,697,723	991,977	2,550,739	1,333,455	1,111,495	22,685,389	34,530,549
12,683,110	1,288,266	57,862,425	16,994,907	991,977	2,596,137	1,333,455	1,262,524	23,179,000	34,683,425
12,683,110	1,288,266	60,798,591	17,528,831	991,977	2,677,699	1,333,455	1,341,432	23,873,394	36,925,197
12,683,110	1,288,266	62,977,956	17,881,422	991,977	2,731,561	1,333,455	1,420,340	24,358,755	38,619,201
12,683,110	1,288,266	65,587,321	18,762,900	991,977	2,866 215	1,333,455	1,499,248	25,453,795	40,133,526
12,683,110	1,288,266	65,587,321	18,762,900	991,977	2,866,215	1,333,455	1,499,248	25,453,795	40,133,526
12,683,110	1,288,266	65,587,321	18,762,900	991,977	2,866,215	1,333,455	1,499,248	25,453,795	40,133,526
12,683,110	1,288,266	65,587,321	18,762,900	991,977	2,865,215	1,333,455	1,499,248	25,453,795	40,133,526
12,683,110	1,288,266	65,587,321	18,762,900	991,977	2,866,215	1,333,455	1,499,248	25,453,795	40,133,526
12,683,110	1,288,266	65,587,321	18,762,900	991,977	2,866,215	1,333,455	1,499,248	25,453,795	40,133,526
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
12,683,110	1,288,266	65,587,321	18,762,900	991,977	2,866,215	1,333,455	1,499,248	25,453,795	40,133,526
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
12,683,110	1,288,266	65,587,321	18,762,900	991,977	2,866,215	1,333,455	1,499,248	25,453,795	40,133,526
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
12,683,110	1,288,266	65,587,321	18.762,900	991,977	2,866,215	1,333,455	1,499,248	25,453,795	40,133,526
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
12,683,110	1,288,266	65,587,321	18,762,900	991,977	2,866,215	1,333,455	1,499,248	25,453,795	40,133,526
634,155,500	64,413,300	3,255,871,676	932,196,283	49,598,850	142,402,026	66,672,750	74,101,199	1,264,971,108	1,990,900,568

Table G-1. (Continued)

3. Farm Size 0.5-1.0 ha.

Item	After irrigation	Before irrigation	Difference
Crop production	17,942	12,054	
Livestock production	4,092	4,432	
Rental value of dwelling	1,514	1,639	
Value increase of crops and livestock	440	133	
Non-farming receipts	6,935	7,015	
Gross farm receipts	30,923	25,273	5,650
Farm expenses	8,788	6,579	
Hired labor	1,206	963	
Depreciation on house and farm implements	508	518	
Livestock purchased	747	779	
Total farm expenses	11,249	8,839	2,410
Living allowance (wage for family labor)	16,760	15,107	1,653
Payment capacity	2,914	1,327	1,587
Payment capacity per ha.			1,983

Table G-1. (Continued)

4. Farm Size 1.0-3.0 ha.

Item	After irrigation	Before irrigation	Difference
Crop production	33,818	17,682	
Livestock production	6,253	7,112	
Rental value of dwelling	2,029	1,964	
Value increase of crops and livestock	702	151	
Non-farming receipts	7,452	5,394	
Gross farm receipts	50,254	32,001	18,253
Farm expenses	15,221	9,976	
Hired labor	2,620	1,515	
Depreciation on house and farm implements	833	864	
Livestock purchased	829	1,127	
Total farm expenses	19,503	13,482	6,021
Living allowance (wage for family labor)	23,326	18,309	5,017
Payment capacity	7,425	210	7,215
Payment capacity per ha.			4,842

Appendix G

Table G–1. Farmers' Repayment Capacity per Farm Household, by Farm Sizes

Unit: NT$

1. Average Farm Size

Item	After irrigation	Before irrigation	Difference
Crop production	25,422	14,269	11,153
Livestock production	5,145	5,546	401
Rental value of dwelling	1,715	1,694	21
Value increase of crops and livestock	866	41	825
Non-farming receipts	6,720	5,959	761
Gross farm receipts	39,868	27,509	12,359
Farm Expenses (deduct water fee)	12,191	7,321	
Hired labor	1,860	1,174	
Depreciation on house and farm implements	686	664	
Livestock purchased	771	884	
Total farm expenses	15,508	10,043	5,465
Living allowance (wage for family labor)	19,819	17,069	2,750
Payment capacity	4,541	397	4,144
Payment capacity per ha.			3,667

Table G–1. (Continued)

2. Farm Size Less than 0.5 ha.

Item	After irrigation	Before irrigation	Difference
Crop production	7,329	5,148	
Livestock production	3,520	4,224	
Rental value of dwelling	987	944	
Value increase of crops and livestock	335	— 624	
Non-farming receipts	5,879	5,973	
Gross farm receipts	18,050	15,665	2,385
Farm expenses	4,785	3,705	
Hired labor	666	471	
Depreciation on house and farm implements	413	379	
Livestock purchased	440	484	
Total farm expenses	6,304	5,039	1,265
Living allowance (wage for family labor)	13,912	13,459	453
Payment capacity	— 2,166	— 2,833	667
Payment capacity per ha.			1,905

Table G-1. (Continued)

5. Farm Size 3.0-5.0 ha.

Item	After irrigation	Before irrigation	Difference
Crop production	60,031	31,943	
Livestock production	10,806	6,062	
Rental value of dwelling	2,480	2,304	
Value increase of crops and livestock	7,030	1,326	
Non-farming receipts	5,147	2,304	
Gross farm receipts	85,494	43,939	41,555
Farm expenses	24,448	11,052	
Hired labor	3,760	2,192	
Depreciation on house and farm implements	1,575	1,103	
Livestock purchased	1,248	847	
Total farm expenses	31,031	15,194	15,837
Living allowance (wage for family labor)	29,526	22,954	6,572
Payment capacity	24,937	5,791	19,146
Payment capacity per ha.			5,801

Source: "Farm-Economy Survey of Ta-Pu Area," Joint Commission on Rural Reconstruction and Provincial Water Conservancy Bureau, 1961.

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