PN-ABL-930
ISN 48664

AGENCY FOR INTERNATIONAL DEVELOPMENT
PPC/CDIE/DI REPORT PROCESSING FORM

ENTER INFORMATION ONLY IF NOT INCLUDED ON COVER OR TITLE PAGE OF DOCUMENT

1. Project/Subproject Number

2. Contract/Grant Number: DAN-4084-Z-00-8034-00

3. Publication Date: March 1992

4. Document Title/Translated Title

Trends and Determinants of Irrigation Investments in the Philippines
APAP II Collaborative Research Report No. 321

5. Author(s)

1. Yolanda Azarcon
2. Randolph Barker
3.

6. Contributing Organization(s)

7. Pagination

8. Report Number: Collab. Res. Rpt. 321

9. Sponsoring A.I.D. Office: A.I.D/R+D/AGR

10. Abstract

Irrigation development was an important driving force in promoting the growth of rice productivity in the Philippines in the 1970s. However, a number of factors have led to the slowdown in irrigation investment in the 1980s. The appropriate level of investment in irrigation has become a matter of considerable debate. To be able to develop a suitable public investment strategy for irrigation in the Philippines, the causal mechanisms that drive the decision-making process must be clearly understood.

A distributed lags model was constructed depicting the major factors influencing the investment decision-making process at the national aggregate level using time series data for the period 1966 to 1987. Separate sets of equations were specified for investments in national and communal irrigation systems because of significant differences in their scale, funding sources and gestation period.

The analysis indicates that a cyclical pattern currently exists in investments in irrigation systems. After reaching a peak in 1980, investments fell to less than a third of their 1980 level by the mid to late 1980s. There is now a growing concern in the Philippines that a slowdown in irrigation investment coupled with a tapering of growth in yields of rice will lead to higher rice prices and higher import levels in the 1990s. Investments in large storage irrigation systems typically funded by foreign donors will not come on stream in time to release any near term shortfall in rice supply. Difficult and costly adjustments may be needed to increase rice production significantly in the short run, should this be necessary.

11. Subject Keywords (optional)

1. 4.
2. 5.
3. 6.

12. Supplementary Notes

13. Submitting Official

14. Telephone Number

15. Today's Date: 3 aug 92

DO NOT write below this line

16. DOCID

17. Document Disposition: DOCRD [ ] INV [ ] DUPLICATE [ ]

AID 590-7 (10/88)

PN-ABL-930

AGRICULTURAL POLICY ANALYSIS PROJECT, PHASE II

Sponsored by the

U.S. Agency for International Development

Assisting AID Bureaus, Missions and Developing Country Governments
to Improve Food and Agricultural Policies

Prime Contractor:	**Abt Associates Inc.**
Subcontractors:	**Harvard Institute for International Development, Harvard University**
	Food Research Institute, Stanford University
	North Carolina State University
	Abel, Daft & Earley
	International Science and Technology Institute
	International Food Policy Research Institute

Project Office 4800 Montgomery Lane, Suite 500, Bethesda, MD 20814 • Telephone: (301) 913-0500 • Telex: 312636

AID Contract No. DA[illegible]-4084-Z-00-8034-00

PN-ABL-930

AGRICULTURAL POLICY ANALYSIS PROJECT, PHASE II

Under contract to the Agency for International Development, Bureau for Science and Technology, Office of Agriculture
Project Office Hampden Square, 4800 Montgomery Lane, Suite 500, Bethesda, MD 20814 • Telephone: (301) 913-0500
Telex: 312636 • Fax: (301) 652-7530 • Fax: (301) 652-7791

TRENDS AND DETERMINANTS OF IRRIGATION INVESTMENTS IN THE PHILIPPINES

March 1992

APAP II
Collaborative Research
Report No. 321

Prepared for

Agricultural Policy Analysis Project, Phase II (APAP II)
A.I.D. Contract No. DAN-4084-Z-00-8034-00

Authors: **Yolanda Azarcon**
Randolph Barker

Prime Contractor: **Abt Associates Inc.,** 55 Wheeler Street, Cambridge, MA 02138 • (617) 492-7100

Subcontractors: **Harvard Institute for International Development,** Harvard University, One Eliot Street, Cambridge, MA 02138 • (617) 495-2164
Food Research Institute, Stanford University, Stanford, CA 94305-6084 • (415) 723-3941
North Carolina State University, Department of Economics and Business, Box 7645, Raleigh, NC 27695-7645 • (919) 737-7187
Abel, Daft & Earley, 1410 King Street, Alexandria, VA 22314 • (703) 739-9090
International Science and Technology Institute, 1129 20th Street, NW, Suite 800, Washington, D.C. 20036 • (202) 785-0931
International Food Policy Research Institute, 1776 Massachusetts Avenue, NW, Washington, D.C. 20036 • (202) 862-5600

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES iii

LIST OF ACRONYMS iv

ACKNOWLEDGEMENTS v

ABSTRACT vi

EXECUTIVE SUMMARY vii

1. INTRODUCTION 1

2. THE WORLD RICE MARKET 2

3. GOVERNMENT IRRIGATION INVESTMENT POLICY 4

4. TRENDS IN NATIONAL RICE PRODUCTION AND IRRIGATED AREA 6

5. PUBLIC INVESTMENT TRENDS IN IRRIGATION 7

6. THE INVESTMENT DECISION-MAKING PROCESS 8

7. MODELING DETERMINANTS OF IRRIGATION INVESTMENT 11

8. DISCUSSION OF EMPIRICAL RESULTS 13

9. RESEARCH EXTENSIONS AND POLICY IMPLICATIONS 15

TABLES AND FIGURES 17

BIBLIOGRAPHY

LIST OF TABLES AND FIGURES

Page

TABLES

Table 1 Philippines: Rice Production, Area and Yield, 1966-88 18

Table 2 Asian Development Bank (ADB) and World Bank (WB) Loan Approvals for Irrigation, 1969-1984 in US$ Million 19

Table 3 NIA Releases for Capital Expenditures, 1966-1989 in Million Pesos 20

Table 4 Generated Service Area, 1966-1989 in hectares 21

Table 5 Definition of Variables 22

Table 6 Summary of Alternative Specifications Dependent Variable Foreign Irrigation Loan Approvals (FLA) 23

Table 7 Dependent Variable--Real NIA Capital Releases (NKR) NIA National Systems 24

Table 8 Summary of Alternative Specifications Dependent Variable NIA Generated Service Area (GSA) NIA National Systems 25

Table 9 Summary of Alternative Specifications Dependent Variable NIA Capital Releases (NKR) NIA Communal Systems 26

Table 10 Dependent Variable Generated Service Area (GSA) NIA Communal Systems 27

FIGURES

Figure 1 World Rice and Wheat Prices, 1950-1990 at Constant 1985 Prices 28

Figure 2 National Systems Model 29

Figure 3 Communal Systems Model 30

LIST OF ACRONYMS

ADB	Asian Development Bank
CDC	cash disbursement ceiling
DBM	Department of Budget and Management
FLA	Foreign Irrigation Loan Approval
GDP	gross domestic product
GSA	Generated Service Area
IRRI	International Rice Research Institute
ISPAN	Irrigation Support Project for Asia and the Near East
NEDA	National Economic Development Authority
NIA	National Irrigation Administration
NKR	National Irrigation Administration Capital Releases
O&M	operation and maintenance
OPEC	Organization of Petroleum Exporting Countries
PIDS	Philippine Institute for Development Studies
RIO	Regional Irrigation Offices
WB	World Bank

ACKNOWLEDGEMENTS

This report was prepared under the Agricultural Policy Analysis Project, Phase II (APAP II), as part of a series of agricultural policy analysis studies for A.I.D.'s Asia Near East Bureau. APAP II is managed and partly funded by the Bureau for Research and Development of A.I.D./Washington. Abt Associates Inc. implements APAP II in collaboration with Harvard Institute for International Development; the Food Research Institute, Stanford University; North Carolina State University; Abel, Daft & Earley; the International Science and Technology Institute; and the International Food Policy Research Institute.

Yolanda Azarcon is an Economic Analyst with the World Bank Resident Mission in the Philippines. Randolph Barker is a Professor with the Department of Agricultural Economics, Cornell University.

This article draws from Azarcon's M.S. thesis submitted to the Department of Agricultural Economics at Cornell University. The comments of Cristina David, Mark Svendsen, Mark Rosegrant and C.M. Wijayratna on earlier drafts are gratefully acknowledged.

Nonetheless, any errors remain the authors'.

ABSTRACT

Irrigation development was an important driving force in promoting the growth of rice productivity in the Philippines in the 1970s. However, a number of factors have led to the slowdown in irrigation investment in the 1980s. The appropriate level of investment in irrigation has become a matter of considerable debate. To be able to develop a suitable public investment strategy for irrigation in the Philippines, the causal mechanisms that drive the decision-making process must be clearly understood.

A distributed lags model was constructed depicting the major factors influencing the investment decision-making process at the national aggregate level using time series data for the period 1966 to 1987. Separate sets of equations were specified for investments in national and communal irrigation systems because of significant differences in their scale, funding sources and gestation period.

The analysis indicates that a cyclical pattern currently exists in investments in irrigation systems. After reaching a peak in 1980, investments fell to less than a third of their 1980 level by the mid to late 1980s. There is now a growing concern in the Philippines that a slowdown in irrigation investment coupled with a tapering of growth in yields of rice will lead to higher rice prices and higher import levels in the 1990s. Investments in large storage irrigation systems typically funded by foreign donors will not come on stream in time to release any near term shortfall in rice supply. Difficult and costly adjustments may be needed to increase rice production significantly in the short run, should this be necessary.

EXECUTIVE SUMMARY

Irrigation development was an important driving force in promoting the growth of rice productivity in the Philippines in the 1970s. A number of factors led to the slowdown in irrigation investment in the 1980s. The appropriate level of investment has become a matter of considerable debate. To be able to develop a suitable public investment strategy, several relationships need to be understood. What are the factors that drive irrigation investment decisions in the Philippines? What is the nature of the relationship between government investments in irrigation and the growth of irrigated rice area over time? How has the level of irrigation investments and the expansion of irrigated area in the country been effected by the cyclical trend in world prices and the rising marginal cost of irrigation development? This analysis was conducted to understand the causal mechanisms that drive the decision-making process.

The allocation of public financial resources for irrigation development in the Philippines can be viewed as a sequence of decisions made at three stages: (1) at the level of the international financial institutions granting irrigation loans to the Philippine government, (2) at the level of the national government allocating budgetary resources to the agricultural sector in general and irrigation in particular, and (3) at the level of the National Irrigation Administration (NIA), which disburses funds to new and ongoing projects.

What appears to happen is this: a particular event such as a sharp rise (drop) in the rice price induces a corresponding increase (decrease) in the profitability of irrigation projects. This in turn influences the flow of foreign loan approvals for the construction of irrigation systems and subsequently, the release of NIA funds for project implementation. There is an additional lag before an increase occurs in new irrigated area because of the actual construction period which will vary from project to project. From the initial rise in price to project completion can take a decade or more with large foreign funded projects but only a year or two with small communal projects.

A distributed lags model was constructed depicting the major factors influencing the investment decision-making process at the national aggregate level using time series data for the period 1966 to 1987. Separate sets of equations were specified for investments in national and communal irrigation systems because of the significant differences in their scale, funding sources, and gestation periods. Empirical results from the model estimation indicate that irrigation investment decisions in the Philippines were mainly driven by three factors: trends in the world and domestic rice prices, the real cost of irrigation construction, and the level of overall economic activity in the country.

Our analysis suggests that a cyclical pattern currently exists in investments in irrigation systems. After reaching a peak in 1980, investments fell to less than a third of the 1980 level by the mid to late 1980s. There is now a growing concern in the Philippines that a slowdown in irrigation investment coupled with a tapering off of growth in yields of rice will lead to higher

rice prices and higher import levels in the 1990s. With this concern there is a renewed interest in irrigation development. However, investments in large storage irrigation systems typically funded by foreign donors will not come on stream in time to relieve any near term shortfall in rice supply. Difficult and costly adjustments may be needed to increase rice production significantly in the short run, should this be necessary.

1. INTRODUCTION

Irrigation development was an important driving force in promoting the growth of rice productivity in the Philippines in the 1970s. The rapid growth of the coverage of irrigation was achieved primarily through government investments in large-scale irrigation projects and the rehabilitation of existing communal systems. Philippine government expenditures for irrigation dropped steadily in both absolute and relative terms from 1980 to 1985, with a slight recovery posted since 1986. This slowdown in investments in irrigation may be attributed to several factors. The pressure to undertake investments to enhance rice productivity was significantly abated when rice prices pursued a secular downtrend in the 1980s and the food situation improved worldwide (Takase, 1982). Budgetary and foreign exchange constraints experienced by the Philippine economy also constrained the availability of funds for public infrastructure development.

There seems to be a growing consensus between the government and international aid agencies involved in the Philippines that emphasis should be shifted from expanding irrigation coverage through the construction of new projects to the maximization of returns from existing systems through rehabilitation and increased government allocations for operations and maintenance activities (NIA, 1983, PIDS 1986, Ali 1987, World Bank 1982 and 1987). Other observers perceive that the recent decline in irrigation investments coupled with a decline in yield growth rates due to modern technology has set the stage for a rise in rice prices in the 1990s which in turn will induce new investments in irrigation (Rosegrant 1987 and Levine et. al, 1988).

To be able to map out an appropriate public investment strategy for irrigation in the Philippines, several relationships need to be understood. What are the factors that drive irrigation investment decisions in the Philippines? What is the nature of the relationship between government investments in irrigation and the growth of irrigated rice area over time? How has the level of irrigation investments and the expansion of irrigated hectarage in the country been affected by the cyclical trend in world rice prices and the rising marginal cost of irrigation development?

This study will also pursue the notion that a cyclical pattern exists in irrigation investments. It must be pointed out that the focus of this modelling effort is not in accurately quantifying the contribution of each of the socio-political and economic determinants of irrigation investments in the Philippines, but more in understanding the causal mechanisms that drive the decision-making process, given likely changes in each of these factors. It is of interest to find out how developments in the markets for rice and irrigation and in the general macroeconomic environment work their way into investment decisions in irrigation and subsequently, turn up as additions to new irrigated area in the Philippines.

2. THE WORLD RICE MARKET

A few observations on the world rice market would provide a good backdrop for the discussion of the trends in irrigation investments. Rice tends to be a highly politically sensitive commodity in many developing Asian countries because it is a staple food and an important source of protein and calories as well as a primary source of livelihood among a majority of the rural population.

Several studies have demonstrated that the world rice market is dominated by governments, rather than by individual consumers and producers.[1] Trade is usually conducted to dispose of residual rice supplies and fill unexpected shortfalls in demand relative to domestic production and stocks. Price, procurement, and marketing policies effectively insulate domestic producers and consumers from the workings of the world market in the short-run while irrigation investments largely determine the effectiveness of long-run government rice policy (Siamwalla and Haykin, 1983). The link between world rice prices and production and consumption decisions of private individuals is also weakened by the widespread reliance on concessional sales and government-to-government contracts (Falcon and Monke, 1979). Long run rice production promotion policies are influenced by developments in the world rice market through their impact on long-term relative prices (Petzel and Monke, 1979).

The world rice market exhibited a pronounced cyclical price trend beginning in the second half of the 1960s (Figure 1). World rice production was growing at a modest pace and international prices were fairly stable throughout the first half of the sixties. Prices rose significantly in 1966-68 because of adverse weather conditions and political instability in Asia. They eventually declined with the return of normal weather and the widespread adoption of high yielding varieties, especially among traditional rice importers, during the early part of the seventies (Takase, 1982).

Dramatic price increases were experienced again in the world market in 1972-73 and also, in 1977 because of poor rice and wheat harvests worldwide and the inflationary spirals triggered by the series of OPEC oil price increases. In both instances, minor fluctuations in weather conditions or other market influences in Asia's major rice importing and exporting countries triggered drastic swings in both prices and supplies. In the mid-1970s, many traditional Asian rice importers simultaneously undertook production promotion programs based on irrigation, the cultivation of high yielding varieties and the application of modern chemical inputs in order to reduce their dependence on foreign suppliers. Most exporting countries in Asia likewise expanded their own production capacities while the United States and the members of the European Economic Community extended large subsidies to their grains producers.

---

[1]See for example, Timmer (1975), Timmer and Falcon (1975), Mangahas (1975), Falcon and Monke (1979/80) and other studies in the Stanford Project on the "Political Economy of Rice in Asia."

Rice prices seem to have continued their secular decline in the 1980s. The food situation improved worldwide and the pressure to undertake investments in measures to enhance rice productivity has been significantly abated (Takase, 1982). In view of the high degree of price instability in the world rice market, however, there has been a significant decline in the number and volume of commercial transactions and a substantial increase in search and transaction costs in the world rice market. Over fifty percent of trade is currently covered by long-term government-to-government contracts, counter trade agreements, and concessional sales while domestic handling of the commodity is kept under the control of state trading agencies, import/export quotas, and other trade barriers (Timmer and Falcon, 1975). Many net rice importers have also taken a more cautious position by building up domestic stockpiles and promoting domestic production (Siamwalla and Haykin, 1983).

3. GOVERNMENT IRRIGATION INVESTMENT POLICY[2]

In formulating its irrigation investment policies, the Philippine government has been highly concerned with protecting domestic rice farmers and ensuring the availability of adequate supplies at stable prices to consumers, the latter objective being a more dominant political goal than the former. A review of irrigation investment policy in the Philippines will illustrate how government decisions were motivated by the need to achieve and maintain national self-sufficiency in rice.

The Philippines has traditionally been a net rice importer, albeit a minor participant in world rice trade, such that irrigation investment policies have been sensitive to prevailing trends in the world rice market. The availability of foreign loans and grants augmented limited domestic capital and human resources for irrigation development in the country. These two forces--world rice prices and foreign lending for irrigation--have tended to reinforce each other because international aid agencies evaluate the returns to irrigation investments at prevailing world market prices (Siamwalla and Haykin, 1983).

The unexpected increase in world commodity prices in 1972-73, triggered by political instability and unfavorable weather conditions all over Asia, and the OPEC oil price shock induced an acceleration in international lending and government investment in irrigation which carried over until the early 1980s. Higher and more stable rice yields obtained from the use of chemical inputs and modern varieties in irrigated areas enhanced the profitability of irrigation projects and encouraged the flow of resources into the sector.

International lending as well as real capital expenditures of the Philippine government for irrigation development took a downturn with the collapse of world commodity prices in 1980. The improvement in the food situation worldwide also triggered this slowdown in new investments to expand irrigation coverage in many rice producing countries, including the Philippines. As early as 1982, the World Bank recommended a shift in the irrigation investment strategy of the Philippines amidst the prospect of rice surpluses in the 1980s.

The government's response to this policy environment is apparent not only in the level of its investments but also in the types of projects pursued by the National Irrigation Administration (NIA). While the implementation of ongoing multi-purpose projects was not discontinued, not one new multi-purpose project has been initiated. Instead, the government has concentrated its resources on programs to rehabilitate national and communal systems nationwide and improve the watersheds of large scale reservoir systems in Pantabangan and Magat River Basins. Government equity contributions to the NIA declined since 1983, thereby forcing the agency to draw on corporate funds for financing infrastructure development. The NIA has also

[2]This section draws heavily on the extensive review of government rice policy by Bouis (1982) and the earlier work of Mears (1974). Bagadion (1989) and Alday (1988) concentrate on the history of the NIA. Other references have also been cited in the text.

NIA has also been under increased pressure to repay foreign loans incurred by the Philippine government for irrigation projects with internally generated funds.

Bouis (1982) argued that the domestic policy environment and internal political pressure created by rising domestic rice prices were equally important determinants of Philippine irrigation investment policy. The decline in public investments in irrigation in the early 1980s was further aggravated by the foreign exchange and domestic budgetary constraints occasioned by the debt-induced financial and economic crisis of 1983. The country imposed a moratorium on external debt payments in 1983 following a period of financial and political instability and has since adopted stringent economic measures to keep the fiscal deficit under control and the balance of payments position manageable. Meanwhile, releases for purely locally funded communal systems were stepped up starting in 1987 to generate employment in rural areas and spur economic recovery.

The Philippine experience in irrigation development has also illustrated the role of non-economic factors in the investment process. During the period immediately following the creation of the NIA, internal political squabbles created institutional bottlenecks in the implementation of planned irrigation investments. A more recent example is the delay in the implementation of investments in communal irrigation projects arising from the unavailability of suitable projects in the NIA pipeline and subsequent delays in the release of funds by implementing government units. The current emphasis on maintaining financial viability at all levels of the NIA bureaucracy and the requirement that it generate its own funds to repay foreign financial obligations have also encouraged a shift away from investment in new service areas toward increased emphasis on improving the performance of existing systems. This is being achieved by the rehabilitation of old and deteriorated structures, the enhancement of operation and maintenance (O&M) activities, and in some cases the turnover of O&M systems to local farmer-water management groups.

4. TRENDS IN NATIONAL RICE PRODUCTION AND IRRIGATED AREA

The country's total land area is estimated at 30 million hectares, of which 9.8 million is suitable for cultivation (World Bank, 1982). A desk survey of topological maps of the country conducted by the National Irrigation Administration (NIA) revealed that around 3.1 million hectares is technically irrigable. As of the end of 1988, 1.45 million hectares were reported to have been provided with irrigation infrastructure, close to half of the potential irrigable area. Two crops of rice are grown on much of this irrigated area.

The rapid growth in irrigated area over the last two decades was achieved primarily through government investment in large scale irrigation projects and the rehabilitation and upgrading of existing communal systems. Most foreign assistance to irrigation in the Philippines was concentrated in large systems with storage reservoirs. This resulted in a significant growth in dry season irrigation. Part of the rationale for emphasis on costly storage systems with a long gestation period can be explained by the fact that the highest grain yields could be achieved by applying fertilizer to modern varieties in the dry season.

Table 1 shows the trends in rice production, area, and yield for selected periods from 1966 to 1988. Irrigated area grew sharply in the period from 1966 to 1972, and then grew at close to 2.5 percent for the next decade. In the 1980s, however, the growth rate has declined to 2.0 percent. Close to 70 percent of the irrigated area is concentrated in Luzon, which is the major rice growing region. The rise in irrigated area harvested has been offset by a decline in rain-fed area. Whereas, non-irrigated area accounted for close to 60 percent of the total rice area in the late 1960s, by the late 1980s the situation was almost exactly the reverse. Essentially no new lands have come into rice production during this entire period. In fact, although total rice area harvested has remained fairly constant at between 3.1 and 3.6 million hectares, the land area committed to rice production has decreased while the area double cropped has increased.

Rice yield per hectare grew at over 4 percent during the 1970s but fell to 1.5 percent in the 1980s. Thus, the decline in yield growth is even more dramatic than the decline in the growth of irrigated area. The Philippines imported annually from 200 to 500 thousand metric tons of rice in 1984 and 1985, and in the period from 1988 to 1990. This represents less than 10 percent of domestic needs. The question, however, is whether this quantity will increase significantly in the 1990s.

5. PUBLIC INVESTMENT TRENDS IN IRRIGATION

The commitment of public financial resources to irrigation development increased steadily from 1966 until the end of the 1970s but has dropped off significantly in the current decade. Trends in combined irrigation loan approvals of the World Bank and Asian Development Bank are shown in Table 2. Loan approvals cover only the foreign exchange cost of irrigation projects and are accrued at the time the loan is approved. The NIA capital releases are shown in Table 3. NIA releases consist of foreign exchange and local currency costs, financed out of budgetary appropriations or NIA corporate funds. Eighty to ninety percent of NIA's annual budget goes towards infrastructure expenditures (Cruz, 1986). Funding is obtained from foreign loans and grants, budgetary appropriations, irrigation service fee collections and amortization payments for initial construction costs, management fees[3] and other internal sources of funds.

New additions to NIA service area in national systems (Column 1 of Table 4) fluctuated around 20,000 hectares per annum throughout the 1970s. It registered a marked acceleration towards the end of the decade, rising from 15.8 thousand hectares in 1979 to a peak of 34.6 thousand hectares in 1983, as new areas resulting from financial commitments made in the early 1970s started to come on stream. Appropriations from the national budget started to be released more regularly to the NIA in 1969 while foreign financial and technical assistance for the construction of large scale irrigation projects became available starting in 1972. Following the collapse of world commodity prices in the early 1980s and the consequent World Bank review of the irrigation sector in the Philippines in 1982, annual generated area in NIA national systems has been on a downtrend.

Relative to generated area in national systems, NIA generated service area in communal systems (Table 4, Column 2) has followed the developments in the rice market more closely. New additions to the NIA command area in communal systems reached a peak of around 54,000 hectares in 1975 following the worldwide commodity price boom in 1973/74. New area generation tapered off until 1978 and began to recover again until around 1982 after the second oil price shock in 1979. New investments in communal systems declined in the early 1980s but have picked up again in the late 1980s when small scale irrigation development was included as an important component of the country's rural-based national economic recovery program.

This responsiveness of communal systems to prevailing market trends may be attributed to their shorter gestation period relative to the large scale gravity systems. In the past, their construction was funded from purely domestic sources. Investment decisions could thus be altered more easily than if foreign financing were involved. In recent years, increased foreign resources have been allocated to communal systems development following the prescribed shift investments strategy advocated by international donors owing to their lower capital requirements and shorter payback periods.

---

[3]The NIA is authorized to charge a management fee of 5 percent of the proceeds of foreign loans for project supervision.

6. THE INVESTMENT DECISION-MAKING PROCESS

There are a number of agencies, both national and international, that have a direct or indirect role in the decision-making process with respect to irrigation development in the Philippines. These agencies can be expected to reflect their own policy positions and the views of their constituents. For example, the World Bank and the Asian Development Bank both advocated in the early 1980s a shift from new investment in large storage systems to rehabilitation and communal irrigation. This reflected: (a) the difficulty of justifying projects due to lower grain prices and lower benefit-cost ratios, (b) the impression that returns on past investments were lower than expected due to poor management of irrigation systems, and (c) the desire on the part of the developed nations who control these Banks to invest more heavily in environmental projects.

On the Philippine Government side, the Ministry of Finance and NEDA (National Economic Development Authority) have been cautious about taking on large new foreign loan commitments due to the huge existing foreign debt. In fact, they have encouraged the National Irrigation Administration to raise fee collections and, where feasible, to turn over systems to local control in order to reduce the government financial support for irrigation.

By contrast, the Philippine Congress has recently passed a resolution that *all potentially irrigable lands* be developed in the next ten years (without, of course, saying where the money will come from). This reflects the bias of Congress in desiring to maintain rice self-sufficiency and low rice prices for consumers.

The NIA adjusts its priorities to attract foreign loans. Although this has meant in recent years giving priority to rehabilitation, there is an understandable bias toward building new systems. This bias is reflected in NIA's 1990 Corporate Plan which calls for a major increase in investments in new systems. The NIA can call on recent evidence from the International Rice Research Institute (IRRI) to support the position that new irrigated area will be needed to maintain rice self-sufficiency in the 1990s. IRRI argues that the potential gains from the "green revolution" technology have been almost fully realized in many parts of Asia including the Philippines and that the rate of increase in yield is likely to be slower in the 1990s than in earlier decades. The data from the Department of Agriculture in Table 1 supports this position.

The Department of Agriculture and the National Food Authority, although not directly concerned with irrigation development, would like to limit rice imports, stabilize prices, and maintain some level of price supports or input subsidies in response to pressures from rice farmers.

The ultimate decision as to the rate, timing, and type of irrigation investments rests with the foreign donors, with NEDA which approves foreign loans, and with the Department of Finance which controls the domestic purse strings.

The allocation of public financial resources for irrigation development in the Philippines can be viewed as a sequence of decisions made at three stages: (1) at the level of the international financial institutions granting irrigation loans to the Philippine government, (2) at the level of the national government allocating budgetary resources to the agriculture sector in general and irrigation in particular, and (3) at the level of the NIA which disburses funds to new and ongoing projects.

Potential irrigation projects in the Philippines are first identified by the NIA Regional Irrigation Offices (RIO) and then consolidated and ranked by the Project Development Department at the Central Office. Proposed projects are submitted to the National Economic and Development Authority (NEDA) which screens them for financial and economic viability and consistency with the government's overall development strategy. The NEDA then finalizes the feasibility studies, arranges with multilateral and bilateral aid agencies for foreign funding and programs their implementation, subject to the availability of counterpart domestic funding in the annual infrastructure budget. This annual budget is presented to the cabinet for review and to the legislature for approval.

An appraisal mission is sent by the donor agencies to conduct an independent evaluation of a proposed project only after it has been shown to be consistent with identified national economic priorities.[4] Detailed engineering studies are conducted and the terms and conditions of the loan are negotiated with the government after the financial and economic viability of the project has been established, based on traditional benefit-cost analysis techniques.

It usually takes about nine months to one year for loan application to loan approval and another twelve to eighteen months to undertake preparatory work for project consolidation. However, once the Philippine government and the donor have agreed to proceed with the project, loan approval is essentially guaranteed. The feasibility or project-justification study may affect the design of the project itself, although often not in a positive way. Typically these benefit-cost studies employ assumptions about potential yields and potential area to be irrigated that are unrealistically high but result in very favorable internal rates of return. For example, Ferguson et al. (1989) found that irrigated area as a percentage of design area was, on average, only 55 percent for recent NIA projects (this figure being down from 70 percent in earlier NIA projects and 94 percent in pre-NIA projects). This leads to poor project design and accounts in part for the subsequent concern that completed projects have not lived up to performance expectations.

Once a project has been included in the country's infrastructure program for the year, the Department of Budget and Management (DBM) issues an advice of allotment to NIA, authorizing it to enter into contracts for programmed expenditures. After funds have been committed, NIA applies for the releases of the quarterly cash disbursement ceiling (CDC) to

[4]Most international donor agencies require borrowing countries to spell out their economic goals and objectives and identify the specific projects needed to accomplish these objectives in some form of a development blueprint.

settle outstanding financial obligations or replenish the common fund account against which subsequent disbursements are drawn at the project (Manasan, 1988).

Decisions are made through the chain of command, following a fairly standard sequence of events. While there is feedback of information among the institutions involved in this process, it is assumed that there is a natural unidirectional order of causation among the various stages in the process and that decisions are made on the basis of either exogenous factors or variables whose values are known and have been predetermined in a previous stage.

In this study, this process was depicted as a system of behavioral and accounting equations whose solutions are determined recursively by a set of exogenous and predetermined variables. Error terms are assumed to be uncorrelated across the different stages of the decision-making process.

What appears to happen is this: a particular event such as a sharp rise (drop) in rice prices induces a corresponding increase (decrease) in the profitability of irrigation projects, thereby influencing the flow of foreign loan approvals for the construction of irrigation systems and subsequently, the release of NIA funds for project implementation. There is an additional lag before a change occurs in new irrigated area because of the actual construction period which will vary from project to project.

Figure 2 depicts the sequence of events in investment decision-making in large scale NIA systems. For example, unfavorable weather conditions in most parts of Asia including the Philippines in 1972 led to a sharp rise in world rice prices in 1973 and 1974. Foreign loan approvals for irrigation in the Philippines peaked in 1978, NIA releases in 1980, and NIA generated service area was highest in 1983. Thus, there was a lag of about a decade between the initial event, that is, the poor crop in 1972, and the consequent peak in new area irrigated. As stated above, however, different projects have different gestation periods and it can be noted that the generated service area was relatively high throughout the 1970s. This can be attributed in large part to the increase in profitability of irrigation investments as a consequence of the introduction of modern varieties in 1966 (Hayami and Kikuchi, 1978).

Thus, it appears that the rapid rise in irrigation investment in the 1970s was induced not only by the spread of the Green Revolution technology, but also a sharp rise in world rice prices in 1973-74. Subsequently, it is not surprising that the steady decline in world rice prices until the mid-1980s has been followed by a slackening of investment in Asian irrigation and agriculture in general.

A similar sequential decision-making process with a much shorter lag can be traced for investments in communal systems in Figure 3. Funding for communal systems usually comes from domestic budgetary appropriations which get reverted to the treasury if not committed within the year. In addition, communal systems usually cover a more limited service area and involve simpler structures than those found in national systems such that their evaluation and construction period is also considerably shorter.

7. MODELING DETERMINANTS OF IRRIGATION INVESTMENT

A model was constructed depicting the major factors influencing the investment decision-making process at the national aggregate level using time series data for the period 1966 to 1987. Separate sets of equations were specified for investments in national and communal irrigation systems because of significant differences in their scale, funding sources, and gestation periods. A model of investment decisions in pump systems was not included in this study because of the lack of continuity in the responsibility for decision-making in investments for these types of systems and because they represent only about eleven percent of irrigated area in the country as of December 1988.

In both national and communal systems models, different equations were fitted for the allocation and release of financial resources, including foreign loans and domestic budgetary appropriations, and the generation of new physical irrigated area resulting from these financial investments. In this way, interactions among the participants in the different levels of the bureaucracy were captured without ignoring differences in the determinants of investments across stages and between the different types of irrigation systems in the country.

All domestic financial flows were deflated using the Government Construction Price Deflator while dollar values were deflated using the U.S. Gross Domestic Product (GDP) deflator, both with base year 1982. These adjustments were necessary in order to control for annual fluctuations arising from changes in the general price level.

A leading indicator model, a special case of distributed lags, was adopted in this study to reflect the way in which investment decisions are made on the basis of past information available at the time the projects are evaluated. (Other models such as the Nerlovian distributed lag, were tested with less satisfactory results). The initial choice for the length of the lag was guided by a careful examination of historical plots of the explanatory and dependent variables. To the extent possible, these assumptions were cross checked against results of interviews with government officials and the experience of international donor agencies. The limited number of observations available on irrigation investments in the Philippines severely constrained the choice for possible assumptions regarding the dynamic components of the model developed in this study.

The model for investments in national irrigation systems was specified as a recursive system with three linear equations having the following form:

Foreign Loan Approvals = f(Rice Prices, Rice Imports, National Income)

NIA Capital Releases = f(Foreign Loan Approvals, Rice Prices, Rice Imports, Capital Cost of Irrigation Development)

Generated Service Area = f(NIA Capital Releases, Rice Prices, Rice Imports, National Income)

The communal systems model was set up with only two equations for financial releases and physical accomplishments inasmuch as, until recently, these types of systems were largely funded out of domestic budgetary appropriations. It must also be pointed out that the model attempts to explain annual variations only in the public sector's contribution to investments in communal systems. The private sector is also actively involved in the initial investment in communal systems, usually in the form of labor and material inputs from members of the irrigators' associations, but the NIA database does not assess a monetary value to these contributions.

NIA Capital Releases = f(Rice Prices, Rice Imports, Costs of Irrigation Development, National Income)

Generated Service Area = f(NIA Capital Releases, Rice Prices, Rice Imports, Cost of Irrigation Development, National Income)

8. DISCUSSION OF EMPIRICAL RESULTS

Empirical results from model estimation indicate that irrigation investment decisions in the Philippines were mainly driven by three factors: trends in the world and domestic rice market, the real cost of irrigation construction, and the level of overall economic activity in the country. The variables used in the regression equations are defined in Table 5. The regression results in Tables 6 to 10 highlight the way in which government decision making in national and communal systems differ in a number of respects.

The recursive model is estimated in the set of three equations shown in Tables 6-8. The level of rice imports is a significant determinant of foreign irrigation loan approvals, the lag between a rise in imports and loan approvals being about four years (Table 6). This reflects, in part, the time required for the NIA to develop projects that can be approved for funding by the World Bank or the Asian Development Bank.

There is another two year lag between the loan approval and the NIA capital releases (Table 7). The foreign irrigation loan approval (FLA) provides a significant explanation of the variance in NIA capital releases.

With a three year lag, the NIA capital releases, in turn, provide a significant explanation of NIA generated service area (Table 8). Thus, the total lag time from the rise in imports and world prices to generated service area is nine years.

However, the total explanation of variance in generated service area is very low. Furthermore, although total rice area has remained fairly constant during the 1980s (Table 1), the proportion of rice area irrigated has grown steadily. In 1980 it was around 45 percent and by 1990 it was approaching 60 percent. This suggests that the gestation period, or the time between NIA releases and the completion of a project, may be highly variable from project to project. Unfortunately, we do not have this information by project. Also, a significant portion of the variability in generated area may be explained by the proportion of funds that go into rehabilitation. However, there is a limited number of years of time series observations on investments, especially those pertaining to expenditures for repair and rehabilitation.

The recursive model for communal systems is estimated with two sets of equations shown in Tables 9 and 10. Trend variables or GDP account for most of the explained variance in NIA capital releases, while prices and level of rice imports were not significant. One need only look at Figure 3 to understand why. Clearly, there has been a steady growth over time in NIA investments in communal systems. Domestic prices and level of rice imports were significant explanatory variables in the regression for generated service area (Table 10). However, the generated service area was associated with a decline in the level of rice imports, which is difficult to explain. The results suggest that there has been a strategic decision by NIA to give

more priority to investment in communal systems over time. Unlike the investment in national systems, which have depended on foreign loans, the level of investment in communal systems, although growing steadily, has not been responsive to short run changes in prices or rice imports.

9. RESEARCH EXTENSIONS AND POLICY IMPLICATIONS

The modeling exercise undertaken in this study raises a number of interesting considerations for future research and for the decision-making process for irrigation investments. The model could benefit from a more theoretically rigorous specification of the determinants of public investment behavior and the underlying lag structure. The availability of longer time series and of data on a project by project basis would allow more flexibility in model specification and estimation. For example, account could be taken of the different time lags in the gestation period of each project.

These limitations not withstanding, there are important policy implications from this study. There is a sharp difference of opinion as to what the future holds for Philippine and for Asian agriculture. There are at least three general scenarios which have influenced the thinking of decision makers over the past decade. The most optimistic scenario is based upon the assumption that growth in rice production through normal technological improvements will make it possible for the Philippines to maintain an adequate level of rice self sufficiency (imports of less than 10 percent of total demand in any given year). Advocates of this position have argued that we should reduce the rate of investment in irrigation and encourage the diversification of agriculture to more profitable commodities. This has been perhaps the predominant view in the 1980s.

In a second scenario, the problem is viewed as cyclical. Just as the high prices in the mid-1970s led to an overinvestment in food grain production, now the extremely low prices coupled with increasing foreign debt may have led to an underinvestment. Any rise in food grain prices will lead to more investments and the long term growth in food grain production will be sustained.

The third and most pessimistic scenario is based on the uncertain outlook for new technology and for irrigation. The argument is that the potential for the new "green revolution" technology has been almost fully exploited and that no significant technology breakthroughs are on the horizon. In addition, it is argued that the most suitable lands for irrigation have been developed and that new irrigation development will be at a much higher cost per hectare.

The argument in this paper is that a cyclical pattern currently exists in investment in irrigation systems. After reaching a peak in 1980 (Table 3) investment fell to less than a third of the 1980 level by the mid to late 1980s. The decline in irrigation investment was accompanied by a decline in rice prices both domestically and in the international market. Prices have been rather steady through the mid to late 1980s. However, exports have increased. There is now growing concern in the Philippines that the slowdown in irrigation investment coupled with a tapering off of growth in yields of rice (Table 1) will lead to higher rice prices and higher import levels in the 1990s. With this concern has come a renewed interest in irrigation investment, but our analysis shows that investments in large storage irrigation systems typically funded by foreign donors will not come on stream in time to relieve any near term shortfall in

rice supply. Investments in communal systems and other projects with a short gestation period deserve emphasis in the short-run but may not result in an adequate increase in rice production. Difficult and costly adjustments may be needed to increase rice production significantly in the short run, should this be necessary.

It can be argued that, given the long term nature of irrigation investments, it would be more appropriate to treat irrigation in the manner of a utility or in much the same manner as roads or power. As noted earlier, the decision as to the level of investment in irrigation rests ultimately with the foreign donors, particularly the World Bank, and with the Department of Finance. The major lenders, dealing on a project by project basis, do not see themselves as endogenous actors in the system, capable through their investment decisions of creating cyclical fluctuations in agricultural production. However, it is extremely hard to predict the rate at which new technologies will boost yields. Furthermore, the down scaling of irrigation investment in the Philippines in the 1980s also reflected the serious economic crisis facing the country and could scarcely have been avoided. In retrospect, as noted by Rosegrant et al. (1987), the planned levels of irrigation investment seem tailored to accommodate the financial difficulties experienced by the government rather than meeting long-term food requirements of the country. Our analysis suggests that the near-term outlook for food supplies in the Philippines is not bright.

TABLES AND FIGURES

Table 1 Philippines: Rice Production, Area and Yield, 1966-88

	1966-68	1966-72	1973-78	1979-82	1983-88
Average Annual Growth Rate(%)					
Production	3.2	2.5	5.8	3.1	1.3
Irrigated	5.6	6.4	7.5	5.2	3.2
Non-irrigated	0.3	-3.2	4.0	0.2	0.2
Area Harvested	0.3	1.2	1.3	-1.1	-0.7
Irrigated	3.6	7.3	2.5	2.4	2.0
Non-irrigated	-2.7	-4.5	0.8	-3.9	-3.5
Yield per Hectare	2.8	1.4	4.1	4.2	1.5
Irrigated	2.2	0.3	4.6	2.8	1.5
Non-irrigated	2.9	2.8	3.1	4.3	1.6
Average Yield (metric tons per hectare)					
Irrigated	2.5	1.9	2.3	2.9	3.1
Non-irrigated	1.5	1.2	1.3	1.7	1.9
Area in Rice ('000 hectares')					
Irrigated	1545	1337	1478	1610	1804
Non-irrigated	1830	1887	2067	1916	1471

Source: Based on data from Department of Agriculture, Bureau of Statistics.

Table 2 **Asian Development Bank (ADB) and World Bank (WB) Loan Approvals for Irrigation, 1969-1984 in US$ Million**

	In Current Prices			At Constant 1985 Prices		
	ADB	IBRD	Total	ADB	IBRD	Total
1969	2.5	0.0	2.5	7.0	0.0	7.0
1970	0.0	34.0	34.0	0.0	89.7	89.7
1971	0.0	0.0	0.0	0.0	0.0	0.0
1972	0.0	0.0	0.0	0.0	0.0	0.0
1973	13.8	0.0	13.8	30.9	0.0	30.9
1974	5.8	19.0	24.8	11.9	39.1	51.0
1975	13.5	17.0	30.5	25.2	31.8	57.0
1976	15.0	92.0	107.0	26.4	162.0	188.4
1977	22.0	65.0	87.0	36.3	107.3	143.6
1978	37.5	215.0	252.5	57.6	330.3	387.9
1979	57.7	21.0	78.7	81.5	29.7	111.2
1980	20.0	71.0	91.0	25.9	91.8	117.7
1981	47.0	38.0	85.0	55.5	44.9	100.4
1982	45.3	71.1	116.4	50.3	78.9	129.2
1983	68.9	0.0	68.9	73.6	0.0	73.6
1984	27.9	30.7	58.6	29.8	32.8	62.6
1985	0.0	0.0	0.0	0.0	0.0	0.0
1986	0.0	0.0	0.0	0.0	0.0	0.0
1987	0.0	0.0	0.0	0.0	0.0	0.0
1988	0.0	45.0	45.0	0.0	41.2	41.2
1989	0.0	0.0	0.0	0.0	0.0	0.0
1990	29.0	0.0	29.0	24.5	0.0	24.5

Source: Asian Development Bank, Review of Irrigation Projects.

Constant 1985 prices deflated by the U.S. GNP deflator.

Table 3 **NIA Releases for Capital Expenditures, 1966-1989 in Million Pesos**

Year	Current Terms				At Constant 1982 Prices			
	National	Communal	Pump/ Private	Total	National	Communal	Pump/ Private	Total
1966	0.93	0.49	1.54	2.96	6.23	3.30	10.36	19.89
1967	9.48	0.93	5.70	16.11	59.24	5.81	35.63	100.68
1968	23.22	1.03	11.63	35.89	136.35	6.08	68.32	210.75
1969	23.47	1.19	8.64	33.31	133.05	6.77	49.01	188.84
1970	23.66	1.29	9.47	34.42	115.46	6.30	46.24	168.00
1971	61.53	1.70	17.74	80.97	271.04	7.51	78.15	356.70
1972	119.88	2.99	15.59	138.45	492.12	12.27	63.98	568.37
1973	238.20	6.29	15.00	259.49	827.37	21.85	52.10	901.32
1974	568.12	14.71	23.19	606.02	1232.09	31.91	50.29	1314.29
1975	819.17	32.41	24.89	876.48	1766.22	69.89	53.67	1889.77
1976	832.09	44.28	22.26	898.63	1662.19	88.45	44.47	1795.11
1977	899.44	59.14	13.91	972.49	1666.25	109.56	25.77	1801.57
1978	1088.20	16.06	11.77	1116.03	1851.31	27.32	20.02	1898.66
1979	1360.24	29.8	3.76	1393.80	1931.34	42.31	5.34	1978.99
1980	2251.92	151.13	0.44	2403.49	2751.95	184.69	0.54	2937.17
1981	1968.32	177.84	-	2146.16	2116.25	191.21	0.00	2307.45
1982	1881.46	165.27	-	2046.73	1881.46	165.27	0.00	2046.73
1983	1584.83	195.85	-	1780.68	1440.91	178.07	0.00	1618.98
1984	1074.53	254.83	-	1329.36	654.83	155.30	0.00	810.13
1985	1484.06	221.16	-	1705.22	763.13	113.72	0.00	876.85
1986	834.22	193.23	-	1027.45	407.77	73.83	0.00	554.23
1987	971.06	451.33	-	1422.39	444.83	169.51	0.00	769.97
1988	1320.10	597.23	-	1917.33	547.74	247.80	0.00	795.54
1989	1368.00	697.78	-	2047.78	262.56	262.56	0.00	790.93

Source: National Irrigation Administration.

Table 4 Generated Service Area, 1966-1989 in hectares[a]

Year	National	Communal	Pump/Private	Total
1966	0	3,996	2,900	6,896
1967	0	8,105	2,911	11,016
1968	6,908	7,545	2,183	16,636
1969	26,391	53,810	1,637	82,338
1970	13,862	8,614	1,228	23,704
1971	22,787	3,015	3,685	29,487
1972	20,376	10,524	6,696	37,598
1973	18,353	11,537	2,678	32,800
1974	23,489	29,833	20,086	73,408
1975	19,262	53,805	20,253	93,320
1976	18,030	42,382	9,575	69,991
1977	20,232	39,293	9,848	69,379
1978	17,316	16,623	9,803	45,747
1979	15,763	23,568	3,041	43,170
1980	20,147	27,659	457	48,263
1981	24,918	22,330	0	47,248
1982	28,451	32,021	0	60,472
1983	34,601	14,735	0	49,336
1984	20,008	9,970	0	29,978
1985	21,651	6,292	0	27,943
1986	20,913	3,729	0	24,642
1987	14,963	4,291	0	19,274
1988	14,428	11,520	0	25,948
1989	16,225	11,305	0	27,530

Source: National Irrigation Administration.

New additions to irrigated service area.

Table 5 Definition of Variables

Dependent Variables

* Foreign Loan Approvals (FLA) - Loan approvals by the World Bank and Asian Development Bank (U.S. $ million).

* NIA Capital Releases (NKR) - Includes both foreign loans and domestic sources, including budgetary appropriations and resources generated by NIA (million pesos).

* Generated Service Area (GSA) - A NIA measure of the annual change of the physical stock of irrigated area (thousand hectares for national systems; hectares for communal systems)

Independent Variables

* World Rice Price (WP) - Bangkok price of 5% broken milled rice (U.S. dollars per ton).

* Domestic Rice Price (DP) - Domestic wholesale price for paddy or unmilled rice (pesos per ton).

* Rice imports (RI) - Annual imports of rice (million metric tons).

* Gross Domestic Product (GDP) - (in billion pesos).

* Growth in GDP (GDPA) - annual growth in GDP (percent).

* Real Cost of Irrigation Development (RK) - annual capital cost of NIA systems (million pesos).

* Benefit cost ratio of irrigation project (BCD) - benefit cost ratio of irrigation projects completed in a given year with incremental benefits valued at domestic prices.

* Benefit cost ration of irrigation projects (BCX) - benefit cost ratio of irrigation projects completed in given year with incremental benefits valued at export prices.

* Trend variable (TR).

Table 6 **Summary of Alternative Specifications Dependent Variable Foreign Irrigation Loan Approvals (FLA)[a]**

	(1)	(2)	(3)	(4)
Intercept	-167.510	-172.180	-38.034	-59.774
	(2.87)[b]	(2.54)	(0.48)	(0.68)
RI_{t-4}	0.308	0.284	0.383	0.400
	(2.40)	(2.13)	(2.11)	(2.13)
WP_{t-4}	0.322		0.085	
	(1.49)		(1.77)	
DP_{t-4}		0.040		0.096
		(1.04)		(1.84)
$GDPG_{t-4}$	8.602	10.840		
	(2.46)	(3.63)		
F	9.87	8.65	3.00	3.04
Adj R^2	67.17	63.83	22.04	23.88
DW[c]	1.42	1.56	1.80	1.80
N	14	14	15	15

See Table 5 for listing of variables used.

The figures in parentheses are the t-statistics, calculated as the ratio of the value of the parameter estimate to its standard error. These can be compared directly with the critical values from the t-table to test the hypothesis that the true value of the parameter is zero.

The Durbin-Watson statistic (DW) is used to test for the presence of first-degree autocorrelation among the least squares residuals. Under the null hypothesis of zero order autocorrelation DW would be approximately 2.0. Values of DW close to 0 indicate negative autocorrelation while values close to 4.0 suggest the presence of positive autocorrelation (Kennedy, 1985).

Table 7 Dependent Variable--Real NIA Capital Releases (NKR) NIA National Systems

	(1)	(2)	(3)	(4)
Intercept	307.740	271.339	-230.825	798.521
	(1.15)	(1.68)	(0.62)	(1.68)
FLA_{t-2}	5.639	5.698	5.070	5.700
	(4.49)	(4.27)	(4.67)	(3.76)
RI_{t-2}	1.272	1.198	2.172	1.595
	(1.37)	(1.19)	(2.82)	(1.46)
RK_{t-2}			-0.011	-0.017
			(0.70)	(0.75)
WP_{t-2}			2.870	
			(3.22)	
DP_{t-2}				-0.052
				(0.34)
BCX_{t-2}	37.687			
	(1.94)			
BCD_{t-2}		127.520		
		(1.48)		
F	7.60	6.41	9.79	3.60
Adj R^2	58.59	53.67	71.52	42.63
DW	1.17	1.01	1.60	0.92
N	15	15	15	15

Table 8 **Summary of Alternative Specifications Dependent Variable NIA Generated Service Area (GSA) NIA National Systems**

		(1)	(2)	(3)	(4|5)
Intercept	16,853.869	21,366.958	21,111.639	19,230.035	18,859.876
	(9.36)	(6.64)	(7.68)	(5.09)	(5.44)
NKR_{t-3}	3.298	1.497	1.588	2.406	2.469
	(2.53)	(0.99)	(1.07)	(1.52)	(1.60)
$IMPT_{t-3}$	-9.756	-9.996	-7.653	-7.932	
	(1.34)	(1.39)	(1.06)	(1.11)	
BC_{t-3}		-302.417		-262.092	
		(0.37)		(0.32)	
XBC_{t-3}			-80.394		-73.236
			(0.42)		(0.35)
$GDPG_{t-3}$				17.131	27.857
					(0.12)(0.19)
F	6.38	1.86	1.88	1.78	1.78
Adj R^2	24.05	12.60	12.80	15.46	15.59
DW	1.32	1.70	1.68	1.53	1.52
N	20	19	19	18	18

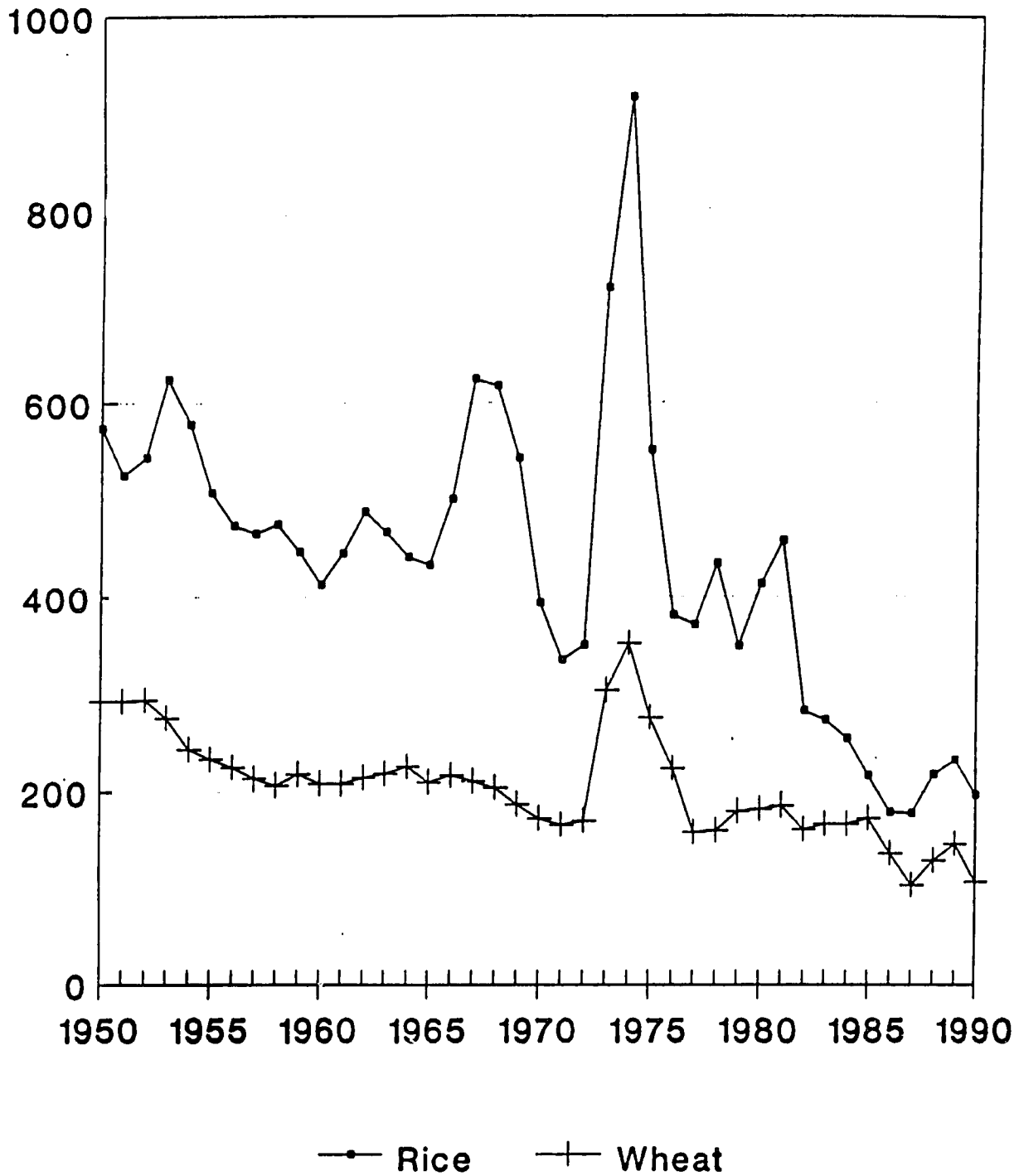
Table 9 **Summary of Alternative Specifications Dependent Variable NIA Capital Releases (NKR) NIA Communal Systems**

	(1)	(2)	(3)	(4)
Intercept	-13.066	56.630	-36.781	-10.007
	(0.41)	(2.68)	(1.06)	(0.31)
RI	-0.080	-0.049	-0.063	-0.006
	(1.36)	(0.69)	(1.09)	(0.10)
GDP	0.243	0.632	0.018	0.353
	(5.40)	(2.33)	(0.12)	(1.36)
WP	0.168		0.070	
	(1.84)		(0.64)	
DP		-0.051		-0.051
		(1.46)		(1.69)
TR			8.570	10.694
			(1.54)	(2.54)
F	12.59	11.47	10.80	12.99
Adj R^2	63.48	61.10	66.21	70.58
DW	1.48	1.26	1.55	1.72
N	22	22	22	22

Table 10 Dependent Variable Generated Service Area (GSA) NIA Communal Systems

	(1)	(2)	(3)	(4)
Intercept	13,787.715	16,590.852	6,198.267	11,935.560
	(2.08)	(1.69)	(0.74)	(1.16)
RK	176.844	82.317	119.975	46.567
	(2.71)	(1.05)	(1.60)	(0.57)
RI	-50.701	-23.534	-46.349	-22.960
	(2.58)	(1.18)	(2.39)	(1.18)
DP	26.732		23.756	
	(2.66)		(2.38)	
WP		35.518		11.805
		(1.12)		(0.33)
GDP	-273.278	-45.693	-287.561	-97.767
	(3.23)	(1.92)	(3.47)	(2.09)
TR			1,870.488	2,243.951
			(1.41)	(1.29)
F	4.99	2.75	4.63	2.62
Adj R^2	43.20	25.04	46.37	27.84
DW	2.67	1.94	2.84	2.06
N	22	22	22	22

Figure 1 World Rice and Wheat Prices, 1950-1990 At Constant 1985 Prices[a]



a/Prices deflated by Manufacturing Index

Figure 2 **National Systems Model**

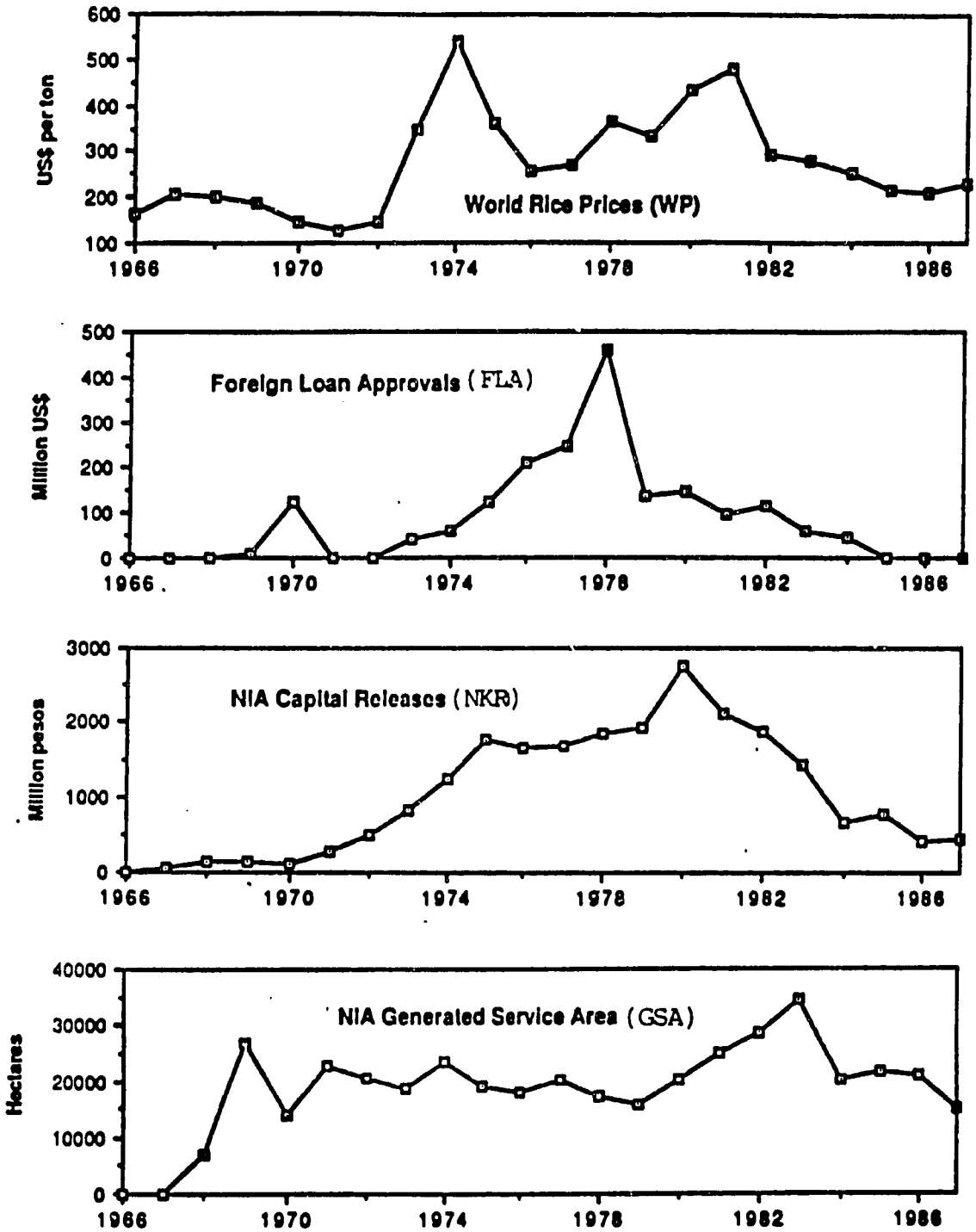
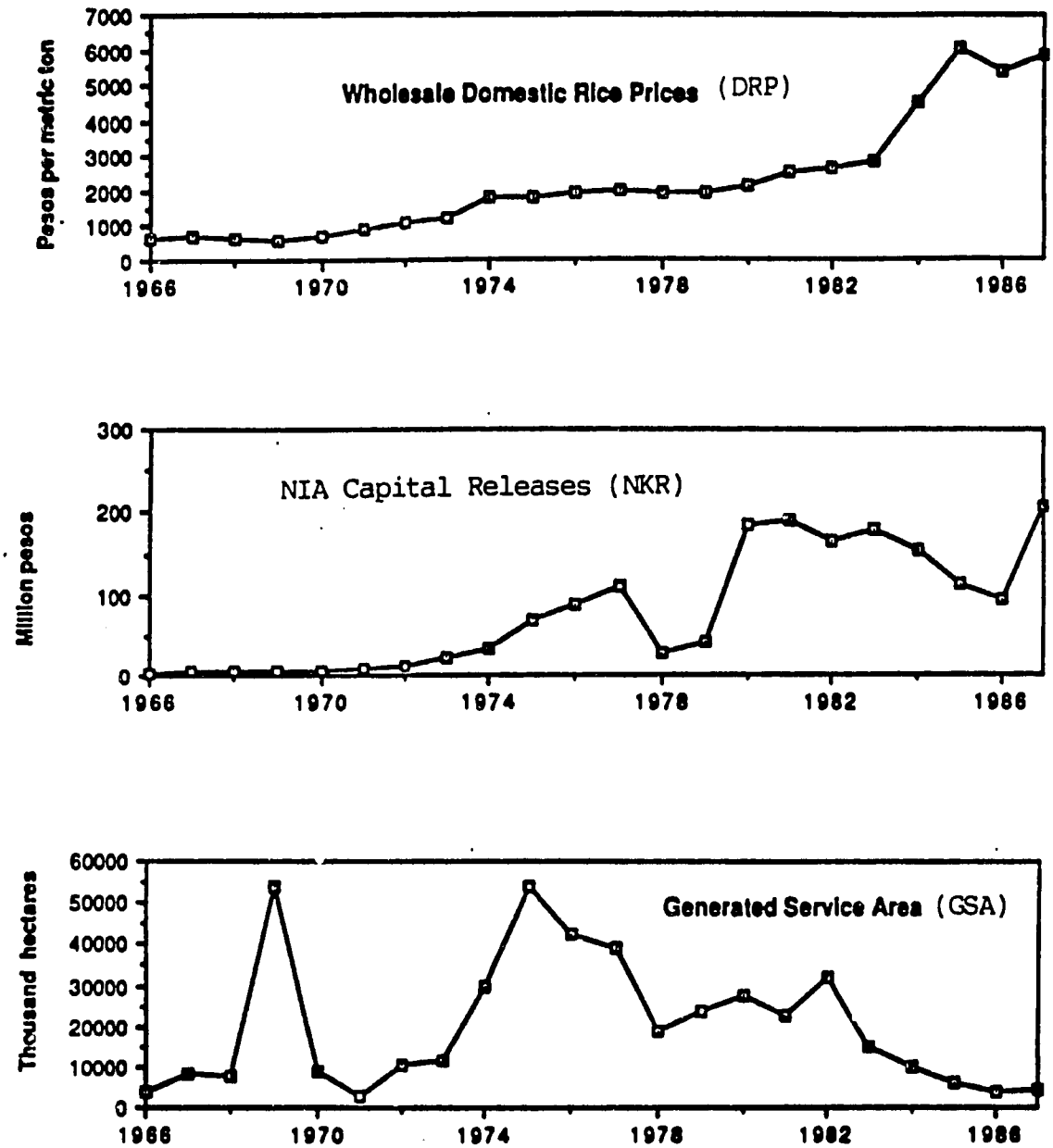


Figure 3 Communal Systems Model



BIBLIOGRAPHY

Adlay, Federico. 1988. "History of Irrigation Development in the Philippines." National Irrigation Administration.

Ali, Ifzal. 1987. "Implications of Falling Primary Commodity Prices for Agricultural Strategy in the Philippines." ADB Economic Staff Paper No. 36. Manila: Asian Development Bank.

Bagadion, Benjamin. 1989. "The Evolution of the Policy Context: An Historical Overview." in Frances Korten and Robert Siy, eds., Transforming a Bureaucracy: The Experience of the Philippine National Irrigation Administration. Manila: Ateneo de Manila University Press.

Barker, Randolph. 1977. "Barriers to Efficient Capital Investment in Asian Agriculture." IRRI Agricultural Economics Department Paper No. 77-14.

Bouis, Howarth. 1982. "Rice Policy in the Philippines." PhD dissertation, Food Research Institute, Stanford University.

Cruz, Wilfrido. December 1986. "The Economics of Irrigation Financing: The Case Against Full Cost Water Charges in the Philippines." Diamond Jubilee Professorial Chair Lecture presented at the University of the Philippines at Los Banos.

Falcon, Walter and Eric Monke. 1979. "International Trade in Rice." Food Research Institute Studies. 17:3.

Ferguson, Carol A., Alfredo Valero and Randolph Barker. 1989. "Lessons Learned About Management Intensities for Effective Performance," Chapter 6 in Irrigation System Management: A Synthesis of Water Management Synthesis II Project Studies, Jack Keller ed.

Hayami, Yujiro and Masao Kikuchi. 1978. "Public Inducements to Public Infrastructure: Irrigation in the Philippines." Review of Economics and Statistics.

Levine, G., R. Barker, M. Rosegrant, and M. Svendsen. 1988. "Irrigation in Asia and the Near East." Paper written for the Irrigation Support Project for Asia and the Near East (ISPAN).

Manasan, Rosario. 1988. "Financing Public Sector Development Expenditure in Selected Countries: Philippines." Manila: Economics Office, Asian Development Bank.

Mangahas, Mahar. 1975. "The Political Economy of Rice in the New Society." Food Research Institute Studies. 14:3:295-309.

Mears, Leon, Meliza Agabin, et. al. 1974. Rice Economy of the Philippines. Quezon City: University of the Philippines Press.

Petzel, Todd and Eric Monke. 1979. "The Integration of the International Rice Market." Food Research Institute Studies. 17:3.

Philippine Institute for Development Studies. 1986. Agenda for Action for the Philippine Rural Sector. Los Banos, Philippines: Agricultural Policy and Research Program, University of Philippines at Los Banos.

Rosegrant, Mark, L.A. Gonzales, H.E. Bouis, and J.F. Sison. 1987. "Price and Investment Policies for Food Crop Sector Growth in the Philippines." Final report submitted to the Asian Development Bank as a component of the Assessment of Food Demand/Supply Prospects and Related Strategies for Developing Member Countries of the ADB.

Siamwalla, Ammar and Stephen Haykin. 1983. "The World Rice Market: Structure, Conduct and Performance." IFPRI Research Report No. 39.

Takase, Kunio. 1982. "Irrigation Development and Cereal Production in Asia." Asian Development Review. 2:2.

The World Bank. 1987. "Philippine Agricultural Sector Strategy Review.

The World Bank. 1982. "The Philippines: Irrigation Program Review.

Timmer, C. Peter and Walter Falcon. 1975. "The Impact of Price on Rice Trade in Asia. in George Tolley and Peter Zadrozny, eds., Trade, Agriculture and Development. Cambridge, MA: Ballinger Publishing Company.

Timmer, C. Peter. 1975. "Political Economy of Rice in Asia: A Methodological Introduction. Food Research Institute Studies. 14:3:191-196.