Water management in public irrigation schemes in Vietnam

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Foreword

Improved water management and more-efficient use of water is an important and topical issue in most countries. The institutional structures for water property rights and pricing regimes for water in most countries have been very complex and usually have not reflected market-based systems. This has meant that water is rarely used efficiently and therefore there is considerable scope for undertaking research that will make significant improvements and thus benefit communities.

ACIAR has been funding a range of projects that have looked at water-use systems and practices in partner countries and Australia. The two projects in Vietnam that are the focus of this impact assessment study are examples of this focus of the Centre's priorities.

Irrigation systems in most of Vietnam, like in many countries, are public systems. Managers and users of these systems have expressed concern about the efficiency of their operations. The two ACIAR projects assessed here examined three systems in different parts of Vietnam and applied techniques that have been used in Australia to more effectively ensure water is delivered at appropriate times and with greater equity.

The projects succeeded in developing hydraulic models to assist with more-effective water-scheduling decisions. The achievement of this objective and consequent changes resulted in farmers receiving water when it was most needed, therefore increasing their crop yields and reducing the oversupply and wastage of water that had previously occurred at some times of the year.

The impact assessment study has shown that the benefits to just the three systems used as case studies have been substantial, amounting around $13 million. The benefit–cost ratio from the research is 10 to 1. The author, David Harris, notes that these estimates are probably conservative because it is expected that the modelling from the projects can be adapted to suit many of the other irrigation systems in Vietnam. This application would be expected to yield similar improvements to the efficiency of these systems.

Peter Core
Director, ACIAR

Contents

Tables

Acknowledgments

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Executive summary

The ACIAR projects LWR2/1994/004 and LWR1/1998/034, 'System-wide water management in publicly managed irrigation schemes in Vietnam', involved research on the efficiency of water management in Vietnam's public irrigation schemes. Three schemes were examined and suggested changes in the operational rules for scheduling water flows have been adopted in each case.

Previous research had raised concerns about the way water resources were managed in public irrigation schemes. The three schemes examined were representative of the different issues affecting water-management efficiency:

- the La Khe and Dan Hoai schemes are primarily river-based extraction systems located in northern Vietnam
- the Cu Chi scheme is gravity fed from a reservoir and is located in southern Vietnam.

Reviews of system performance showed deficiencies in the capacity of the schemes to supply the amount of water required for seasonal cropping demands. In some cases an oversupply of water affected farm performance because the land was waterlogged. In other cases, farms were undersupplied, which affected crop yields through plant water stress.

A lack of financial resources limited the opportunity for improved system performance through the physical development of the existing assets. An alternative way to increase water-management efficiency was to identify ways to improve operational performance.

The overall objective of the projects was to improve the operational efficiency and economic sustainability of publicly managed irrigation schemes in Vietnam. The expected outcome was to recommend changes in operating procedures to achieve a more reliable, timely and equitable supply of irrigation water to farmers.

The projects involved several research activities with specific objectives. The main research activities were to evaluate system performance and develop hydraulic models to assist company management in water-scheduling decisions.

ACIAR funded the projects from January 1995 to December 2003, with total expenditures of A$1.58 million. Project benefits were evaluated separately for each scheme and the evaluation shows that revised rules for scheduling water flows had two benefits.

The primary benefit is a financial gain for farmers from improved crop yields. A closer alignment of water supplies to crop demands increases output from existing planting decisions by reducing water stress or waterlogged land. In some situations, additional benefits may come from increased opportunities to diversify into dryland crops.

A second benefit is obtained through reduced water usage where the existing operational rules contributed to an oversupply of water. Irrigation companies can lower their operating costs through reducing pumping time or lower bulk water costs. This would improve their financial performance and reduce the requirement for public subsidies.

Valuations of the farm-level benefits were based on project impact areas defined as the drainage areas of the irrigation systems. It required an assessment of the yield effect and the seasonal cropping areas affected by the change in operating procedures. The available data suggested there would be a significant yield gain if the revised procedures were fully adopted:

- post-adoption outcomes in the La Khe scheme suggested a yield gain of 0.6 t/ha for spring season rice—an increase of 11% for farms with a significant water deficiency.

In present-value terms, the net benefit of the projects was A$13 million, which implies a benefit–cost ratio of about 10 to 1. A progressive project evaluation up to the end of 2004–05 assessed the net benefits at A$0.3 million with a benefit–cost ratio of 1.2 to 1.

The economic benefits relate to gains in farm-level productivity and reduced costs in providing irrigation services. Higher incomes will help to reduce poverty among the farmers who rely on the irrigation schemes. The benefits are equivalent to an increase in net farm income of between A$29 and A$70 per year. Improved water-management efficiency will also have longer term environmental benefits by reducing soil degradation from increased salinity levels.

1 Background

Agriculture is an important component of the Vietnamese economy with around 80% of the population located in rural areas (FAO 2001). The agricultural sector is mostly based around small-scale family farms. River delta regions are important areas of agricultural production and make a substantial contribution to the financial performance of the rural economy.

Modest rates of economic growth in rural areas have limited the rate of improvement in rural household incomes. Average income levels are lower in rural areas than in many urban areas and rural poverty is an important issue for the central government. The small size of farm holdings has contrubited to the level of rural poverty.

The average farm size is less than 1 ha. Cropping enterprises are predominantly based on rice production, and many farms retain a portion of their rice harvest for home needs. The ability to produce additional crops for commercial sale creates opportunities to raise household incomes.

The availability of irrigation water has enabled the river delta regions to sustain a large number of rural households. It has supported the development of more-intensive farming practices with the production of up to three crops per year. The improved farm performance has helped to raise household incomes and reduce the level of rural poverty in these regions.

Water management in Vietnam's irrigation schemes

The Red River and the Mekong River are among the most highly productive river basins of the rural economy. Farm performance is dependent on the availability of water provided by public irrigation schemes. Increased demand for water for non-agricultural uses and poor management of the existing water resources are important issues for future economic development in these regions:

- the physical and operational efficiency of the public irrigation schemes has a direct impact on farm financial performance in these regions.

The capacity, coverage and standard of infrastructure affects the physical performance of the irrigation schemes. A lack of financial resources has limited the opportunity for improved system performance through maintenance and physical development of the existing assets. An alternative way to improve performance is through better water management and improved operational efficiencies.

Concerns have been raised about the way irrigation water resources are managed. A number of inefficiencies in water management have been identified through a range of research projects. In some situations, water is unevenly distributed across the system. Some farms are oversupplied and others are undersupplied. Other sources of inefficiency include:

- the timing of water releases to meet crop requirements
- losses that occur through unauthorised water use and inadequate infrastructure to minimise leakages
- an inability for the system to meet peak water requirements because of capacity constraints and the poor condition of infrastructure.

Deficiencies in water management can lead to suboptimal water use. This affects crop yields and the level of farm incomes. It can also lead to higher operating costs for systems based on pumping water from a primary source of supply. The inefficiencies in these systems can mean higher water fees for farmers, reduced spending on essential maintenance or higher government subsidies for the companies that manage the system:

- many irrigation companies rely on public subsidies to remain financially viable.

While the deficiencies in water management are due to inadequate infrastructure and maintenance programs, they also reflect poor service delivery and operating rules that fail to supply enough water to meet crop demands at different points of the production cycle. Inadequate water delivery schedules have affected agricultural production in some areas:

- alternative operational rules could improve farm performance
- a model-based approach to scheduling water deliveries, built on quantified crop demands, could help to develop alternative operating procedures.

Research that leads to improved water management could provide significant economic benefits to the rural economies of the river delta regions. Benefits may be obtained through improved farm performance resulting in higher household incomes. There could also be cost savings for the companies that manage the irrigation schemes. The ACIAR projects, 'System-wide water management in publicly managed irrigation schemes in Vietnam' (LWR2/1994/004 and LWR1/1998/034), are examples of research that has addressed this issue.

2 Public irrigation systems in Vietnam

Vietnam has abundant rainfall that averages around 1,800 mm per year. The annual distribution is highly uneven because the country lies in a tropical monsoonal region. Typically 80–85% of the total rainfall occurs in the wet season. Consequently, irrigation systems play an important role in managing water resources for agricultural production:

- Vietnam has around 3.5 million ha of irrigated agriculture.

Irrigation schemes are based around the major river basins and are managed by government institutions. The schemes draw water from the river basins to meet the demands of agricultural producers in the dry season. In some cases they are also used for water drainage to manage the flooding that can occur during the peak of the wet season.

The structure of irrigation services

There are nine major river basins in Vietnam. The Red River and the Mekong River regions are among the most highly productive regions in the country. Most river basins are located across several provinces. This means a number of government institutions can be involved in the management of irrigation services located in each river basin:

- this creates institutional complexities that can affect the operational and financial performance of the companies that manage the irrigation schemes.

In general, the organisational structure for irrigation services revolves around a bulk water supply company. irrigation and drainage management companies (IDMCs) are generally operated by provincial governments. Increasingly, however, the central government has taken administrative control of IDMCs where their jurisdiction covers several provinces:

- central control by the Ministry for Agriculture and Rural Development (MARD) is often necessary because of difficulties is gaining agreement on water charges and administrative issues.

Some IDMCs directly manage the primary irrigation services, which include water supply and the maintenance of distribution infrastructure. Others deliver bulk water to an irrigation company that is a semi-autonomous management unit that answers to a provincial government. These companies are responsible for the operation and management of the main water-supply canals for a specific irrigation system.

Irrigation services at the commune level are managed by agricultural cooperatives through water management groups (WMGs). The WMGs administer water distribution to farmers and maintain the infrastructure attached to the main supply canal. They also collect fees for the irrigation and drainage services on behalf of the irrigation companies or the IDMCs:

- irrigation fees are determined by the provincial government and are related to the seasonal average crop yields.

The financial performance of irrigation companies

Farmers are not charged for the volume of water they use. They are charged a fixed fee based on the area of their irrigated crop land. This is the most practical method for collecting fees. There is no infrastructure to monitor the volume of water usage by the large number of small-scale holdings in the commune.

Fees vary according to the type of irrigation scheme. There are three types of schemes:

- extraction schemes that pump water from a river
- gravity-supplied schemes that draw water from reservoirs
- partial gravity-supplied schemes that use pumps to supply parts of the system.

Farmers pay a fixed seasonal fee for water based on a five-year moving average of the seasonal rice yield for the province. The fee is notionally fixed at approximately 8% of average rice yields, but in reality the charging rate is significantly lower. The exact fee is expressed as kg/ha of rice but is paid in Vietnamese dong (VND) on the basis of a nominated price of rice:

- the price is set on a seasonal basis by the provincial government and is generally less than the market-determined price of rice
- the same seasonal fee is paid regardless of the types of crops that are planted and the amount of irrigation water used.

The fees charged to individual farmers are generally insufficient to cover the costs of operating the irrigation schemes. There is no attempt to recover the cost of depreciation of the physical assets, and funding for infrastructure maintenance is inadequate. Where specific drainage fees are charged they often do not cover the full costs of pumping water:

- revenue shortfalls from inadequate pricing structures are higher when farmers do not pay the required fees.

Extraction-based schemes have costs associated with pumping and draining water to meet the seasonal requirements of farmers. These costs will vary according to fluctuations in crop growing conditions and the severity of flooding. Short-term fluctuations in energy consumption can often create budgeting difficulties for the companies that manage these types of schemes.

As the irrigation companies are public entities, the revenue shortfalls have generally required government subsidies. The size of these subsidies has increased in recent years. Over time, the monopoly position of these companies and expectations of government assistance have contributed to a culture of poor cost management:

- insufficient competition and accountability have contributed to operational inefficiencies that affect water management.

To some extent, the pricing structures reflect the political concerns of imposing full cost recovery on farmers with limited incomes. A public subsidy is provided in recognition of the social welfare and equity considerations. The effect of these arrangements is that the financial performance of the irrigation companies has become reliant on political decisions about charging rates and the amount of public subsidy.

A further consequence is that irrigation companies do not retain sufficient revenue to cover their requirements for infrastructure maintenance and development. This has led to a decline in the physical assets used for water distribution (e.g. canals, off-take gates). Inadequate maintenance reduces the reliability of the irrigation system and contributes to operational inefficiencies that affect water management.

Improvements in water management can be achieved through:

- effective maintenance of the existing irrigation and drainage infrastructure
- investments in infrastructure improvements
- efficiency gains in the operational procedures for the primary delivery system.

ACIAR provided funding for research that focused on improving the operational performance of three irrigation schemes: the Cu Chi irrigation scheme, located on the Saigon River in the Dong Nai Province of southern Vietnam, and the La Khe and Dan Hoai schemes in the Red River Delta in the north of the country.

The Cu Chi irrigation scheme

The Cu Chi irrigation scheme is a gravity-supplied system that draws water from the Dau Tieng reservoir in Dong Nai Province. The reservoir regulates water supplies on the Saigon River. It supplies domestic water to parts of Tay Ninh Province and Ho Chi Minh City. It also provides flood control protection in the wet season and regulates salinity levels in the lower delta regions.

The Dau Tieng reservoir supplies water to irrigation companies that service around 170,000 ha of agricultural land. The Cu Chi scheme services a drainage area of around 14,500 ha. Operational rules are designed to provide a constant supply of water because the main supply canal does not contain the infrastructure to regulate the flow of water (George et al. 2003):

- the constant water flow creates the potential for suboptimal water management
- it affects farm performance when crop land becomes waterlogged—it reduces crop yields and limits the options for crop diversification.

The Cu Chi scheme is a typical example of irrigation based on water retention and control through a reservoir. These schemes have lower operating costs than pump-based systems as they have limited energy requirements, but have additional expenditures in the form of bulk water fees paid to the company that manages the reservoir system.

The tropical monsoon climate in southern Vietnam creates two seasons. The wet season from May to October accounts for around 90% of the annual rainfall. The limited rainfall that occurs in the dry season, means that irrigation is required to sustain agricultural production. Average rainfall is 1,861 mm per year.

The structural characteristics of irrigated agriculture in the Cu Chi scheme are similar to other parts of the country. Flood irrigation is mostly used to support paddy rice production. Dryland crops that require smaller amounts of irrigation water are becoming more prevalent. In the dry season, some farmers have diversified into other crops such as maize and peanuts:

- there is no crop diversification in the wet season because the heavy rainfall makes the growing conditions unsuitable.

While the alternative crops have lower water requirements, the standard seasonal irrigation fee based on the rice-yield formula still applies. This pricing structure limits the incentive for farmers to diversify. There are also complications in managing water application rates for different crops because the operational rules of the system are based on a continuous supply of water.

Agricultural production from the Cu Chi scheme is based around three cropping seasons:

- the winter/spring (dry) season—December to March
- the summer/autumn season—April to July
- the main (monsoon) crop season—August to November.

Rice is grown in the summer/autumn and main crop seasons. There is no irrigation requirement in the main crop season because of the high rainfall. Irrigation is essential for crop production in the winter/spring season and water is also supplied in the summer/autumn season. In recent years higher returns have encouraged crop diversification in the upland areas of the service area:

- diversification occurs in the winter/spring season and has mostly involved peanuts and maize—there is no crop diversification in the other two seasons.

In the winter/spring season, the area planted to alternative crops varies from year to year. Rice is grown in the submerged lowland areas. Peanuts and maize are grown in the upland areas where the groundwater table is lower. Some of the irrigation area is used for fruit and vegetable production and some for aquaculture.

The gross drainage or service area for the scheme is 14,500 ha. However, a portion of the service area is permanently unavailable for agricultural production because of other land requirements such as roads, housing and infrastructure. This means the irrigation service area is smaller than the full drainage area.

The area of available irrigation land is not fully used in each of the three cropping seasons. Farms have the potential to grow three crops per year, but this does not occur in all cases. The managers of the Cu Chi scheme indicated that the area used in the summer/autumn season is significantly smaller than the area used in the winter/spring season:

- in 2003–04 about 42% of the gross service area was used for irrigated crop production in the winter/spring season
- about 23% of the service area was used in the summer/autumn season.

Preliminary investigations indicated that there were two areas of deficiency in water management in the Cu Chi scheme:

- an excess supply of water for diversified cropping in the winter/spring season
- an uneven water distribution across the system.

The excess supply of water in the winter/spring season affects farm output in some parts of the system. Yields for alternative crops are reduced because the land becomes waterlogged and salinity levels have been rising. A further potential effect is that the incentive for diversification may be reduced in some areas because the operation of the system does not allow for adequate control of water applications.

The uneven distribution of irrigation water affects rice production outside the main season. Some parts of the system experience water deficiencies that lead to lower rice yields when the crop suffers water stress at critical points of plant growth. The impact on yields affects only a portion of the system as some parts of it experience no water deficiency:

- project benefits are obtained from improved water management in both the winter/spring and summer/autumn seasons.

The La Khe and Dan Hoai irrigation schemes

The Red River Delta (RRD) has 31 irrigation schemes servicing around 850,000 ha of irrigated agriculture (Turral and Malano 2002). This represents about a quarter of Vietnam's total area of irrigated agriculture. Most of the irrigation area is served through pump-based extraction systems. Only 18% of irrigated agriculture in the RRD is supplied by gravity-fed systems.

The RRD irrigation systems serve a dual purpose: they supply water for flood irrigation of rice crops during the dry season and they drain floodwaters from crop land in the wet season. The extensive use of pumping stations means there are substantial energy costs in operating RRD irrigation schemes. There are 1,700 pumping stations operating in the delta, using more than 7,500 sets of pumps (George et al. 2004):

- energy costs typically account for 30–35% of total operating costs for these systems.

The La Khe irrigation scheme is a typical example of the pump-based irrigation systems in the RRD. It is located 25 km south of Hanoi and supplies water to 8,650 ha of irrigated crop land. An area of around 3,000 ha is irrigated directly from two rivers that border the service area. The remaining 5,650 ha is supplied by a primary canal that is linked to a pumping station:

- La Khe is among the more energy efficient systems operating in the RRD.

The condition of the La Khe hydraulic infrastructure is generally poor (Turral et al. 2002). Design limitations affect the efficiency of the operating procedures and anecdotal reports suggest some farmers may be extracting more than their entitlement. These structural deficiencies affect the reliability of the system and the adequacy of water distribution within the system.

Operational rules for the La Khe scheme were poorly specified with a water-pumping schedule imposed on the system. In some cases, the secondary canals supply more than one commune and there can be coordination problems among the various user groups. Historically, the pumping schedule was only loosely correlated with the crop planting schedules of the communes:

- operational procedures and infrastructure limitations affect farm performance because the water distribution is inequitable and water is not supplied in a timely manner.

The Dan Hoai irrigation scheme is also a pump-based system located 25 km from Hanoi. It supplies water to 6,520 ha of irrigated crop land. The main supply canal obtains water from a pumping station and an intake sluice gate. The pumping station is not used when water levels in the RRD allow the sluice gate to supply water to the system:

- the pumping station is generally not used during the summer monsoon season.

The La Khe and Dan Hoai irrigation schemes are typical of the irrigation services located in the RRD. Agricultural production is based around three cropping seasons:

- the winter (short) season—mid-November to mid-February.
- the spring (dry) season—mid-February to May
- the summer (monsoon) season—June to mid-November

Rice is the only crop grown in the summer season and there is no irrigation requirement because of the high rainfall. It is during this period that the irrigation companies provide drainage services to minimise flood damage to the rice crops. There is no rice grown in the winter season and there is no irrigation during this period (Marsh et al. 2003). During this period most farms grow alternative dryland crops such as maize, peanuts and vegetables.

Irrigation is essential for crop production during the spring season. Rice is generally grown in this period, but in recent times there has been some limited crop diversification. It is during this period that the operational deficiencies in both irrigation schemes can lead to water-management issues that affect agricultural production.

The gross drainage area for the two schemes is around 13,000 ha for La Khe and 8,000 ha for Dan Hoai. However, a portion of the service area is unavailable for irrigated agriculture because of other land requirements. The irrigated crop land is estimated to be 8,650 ha for La Khe and 6,520 ha for Dan Hoai.

In both schemes, the area of irrigation land is not fully used in each of the three cropping seasons. Farms have the potential to grow three crops per year, but this does not occur in all cases. All farms produce rice in the summer season. Irrigation areas used in the winter and spring seasons vary, with some farms electing to grow only one extra crop outside the summer season.

Preliminary investigations indicated there was a management issue in the uneven distribution of water across both systems. In both cases, the operational deficiency affects rice production in the spring season. Some areas experience water deficiencies that lead to lower rice yields when the crop suffers water stress at critical points of plant growth. The impact on yields affects only a portion of the system because some areas do not experience a water deficiency:

- there is no indication of water-management issues associated with crop production in the summer and winter seasons in both irrigation schemes
- project benefits are obtained from improved water management in the spring season.

3 The ACIAR projects

ACIAR funded two projects on water management in public irrigation schemes in Vietnam. They investigated the engineering, institutional and economic aspects of the operational performance of three irrigation schemes. Project managers indicated this was a new area of research. The aim was to improve the way the schemes managed water resources, by changing operating procedures.

The first project (LWR2/1994/004) examined the La Khe irrigation scheme in Ha Tay Province. The second project (LWR1/1998/034) extended this work by using the same methodology to examine two other schemes—the Dan Hoai scheme in Ha Tay Province and the Cu Chi scheme in southern Vietnam:

- the first project commenced in January 1995 and was completed in December 1998
- the second project commenced in January 1999 and was completed in December 2003.

Project objectives

Efficiency improvements in water management can provide significant economic benefits for the operators of irrigation schemes and for the users of water-supply services. This can be achieved in various ways. The focus of the ACIAR research was to show how operational performance can be improved without large investments in physical infrastructure.

Improved water management using the existing physical infrastructure can be achieved through changes in the operating procedures that determine the schedule of water deliveries. This requires the development of analytical support tools and institutional processes to assist decision-making by the managers of the irrigation schemes. The overall objective of the research was:

- to improve the operational efficiency and economic sustainability of publicly managed irrigation schemes in Vietnam.

The methodology for both projects involved several research activities with specific objectives. These activities were designed to improve water management by developing:

- hydraulic models to help management in water scheduling
- on-farm water-management guidelines
- institutional structures to support farmer participation in water management
- performance evaluations of rice-based irrigation systems
- a system to assist management in monitoring crop development.

The expected outcome of the projects was to achieve a more reliable, timely and equitable supply of irrigation water to farmers. Efficiency improvements could also lead to reduced overall water-supply requirements. Therefore, the projects could generate economic benefits through:

- higher crop yields through improved water distribution across the irrigation system
- reduced electricity expenditures for pump-based schemes
- reduced expenditures on bulk-water purchases for systems that rely on reservoirs.

Project benefits are assessed for the three schemes examined in the projects. Research results have been distributed to government officials, but there was no indication of a wider adaptation of the research at the time of the evaluation. In time, the research may be adapted and applied to other schemes. This could lead to greater gains in water-management efficiency in Vietnam.

Dimensions of the research

The first project (LWR2/1994/004) was divided into three specific research activities. The first activity involved the development of a modelling tool to assist in the day-to-day scheduling of water deliveries. The model was designed to simulate the operational performance of the La Khe scheme in meeting the seasonal crop demands for water.

The 'irrigation main system operation model' (IMSOP) is a steady-state representation of the hydraulic operation of the main and secondary canals in an irrigation system. It was developed to calculate water supply and demand at defined off-take points according to input data on cropping patterns and soil types. The model allows for transmission losses and determines the accumulated flow requirements starting at the downstream end of the system:

- it is a valuable management tool because it can be used to assess historical performance and to evaluate alternative operational scenarios.

A second research activity involved the development of water-management guidelines for existing and alternative cropping systems. This subproject was designed to improve irrigation scheduling. It allows system operators to account for evaporation rates, rainfall and run-off in determining the required amount of water for particular crops.

A third research activity was an investigation of organisational structures that would facilitate the interaction of water users and system operators in water-management decisions. This research was designed to improve communication, define operational rules for the system and to reduce conflicts among irrigators.

The second project (LWR1/1998/034) also had three research activities. The first activity involved extending the technical and institutional measures from the first project to Dan Hoai and Cu Chi irrigation schemes. A major component of this research was to adapt the IMSOP model to the reservoir-supplied irrigation system at Cu Chi. It also involved:

- developing a pilot scheme to show the benefits of volumetric water pricing
- a trial of advanced surveying systems to support the IMSOP model.

A second research activity involved an evaluation of the impact of changes in water management on irrigated rice production. The impact on cropping yields is an important aspect of the potential project benefits. This activity developed a framework that could be used to evaluate changes in other irrigation systems. It was applied to evaluate the impact of the operational changes that were proposed for the Cu Chi irrigation scheme.

A third research activity focused on new methods to monitor crop development during the season. This research was designed to enhance the data-collection procedures for model simulations. The aim was to improve the accuracy and timeliness of model estimates of water demands. This would improve the accuracy of advice on water scheduling.

Project expenditures

ACIAR funding was initially provided for two projects over seven and a half years from January 1995 to June 2002. A project review was conducted in May 2002 and the external reviewers recommended a project extension until September 2003. The proposed extension was to allow for the completion of several aspects of the second project. This proposal was accepted and additional funds were allocated for the project extension.

Total ACIAR expenditures on the two projects were A$1.58 million (Table 1). After adjusting for inflation, the total expenditures were around A$1.8 million in 2003–04 dollars. A breakdown of expenditures over the course of the two projects was unavailable. For the purposes of this evaluation, the expenditures have been apportioned over the life of the two projects.

Both projects would have involved in-kind funding contributions from other organisations collaborating in the projects. Some in-kind contributions would also have come from the three irrigation companies involved in the research:

- estimates of these in-kind contributions were unavailable
- because in-kind contributions should be included in the project evaluation, the net benefits may be overstated.

Project management and collaboration

The two projects involved the coordination of several institutions in Australia and Vietnam. It required the integration of research methodologies across several disciplines. It also involved the coordination of field trials of the analytical support tools and institutional processes for the three irrigation systems.

Capacity building in applied engineering, scientific and economic research was an important aspect of the project. The project involved extensive collaboration among professional staff trained in a number of disciplines. It also involved intensive in-country training of Vietnamese project staff and associated training activities in Australia.

The ACIAR projects have probably provided some capacity-building benefits in Vietnam. The training and skills development associated with the development of the IMSOP model were a necessary input to the project. The human-capital development of the Vietnamese researchers involved is likely to have strengthened their capacity to undertake similar research:

- it was not possible to assess the value of these benefits because no information was available to facilitate the preparation of a credible estimate
- further investigation of this issue may be worth pursuing in future project evaluations.

The commissioned organisation was the Department of Civil and Environmental Engineering at the University of Melbourne in Australia. The CSIRO Division of Building, Construction and Engineering was a collaborating institution in Australia. In Vietnam, the collaborating institutions were:

- the National Institute for Agricultural Planning and Projection, Hanoi
- the Vietnam Institute for Water Resources Research, Hanoi
- the University of Agriculture and Forestry, Ho Chi Minh City
- the University of Technology, Ho Chi Minh City
- the Southern Vietnam Institute for Water Resources Research, Ho Chi Minh City.

Table 1. Distribution of ACIAR project expenditures (A$)

	La Khe project[a]	Cu Chi, Dan Haoi project[b]	Total expenditures
1994–95	137,338	..	137,338
1995–96	137,338	..	137,338
1996–97	137,338	..	137,338
1997–98	137,338	..	137,338
1998–99	137,338	179,010	316,348
1999–00	..	179,010	179,010
2000–01	..	179,010	179,010
2001–02	..	179,010	179,010
2002–03	..	179,010	179,010
Total	686,692	895,048	1,581,740

a Project expenditures for LWR2/1994/004.

b Project expenditures for LWR1/1998/034 summarised in final report—include cost of project extension.

Source: ACIAR

The two projects also involved the cooperation and involvement of staff and management at three irrigation companies:

- the La Khe Irrigation Company, Ha Tay Province
- the Dan Hoai Water Company, Ha Tay Province
- the Cu Chi Water Company, Ho Chi Minh City Province.

Application of the research results to the three irrigation schemes required extensive training of management at the irrigation companies. Staff were trained to operate the software support tools that were developed by the projects. This was an important aspect of disseminating the research results, as company management had to be convinced of the benefits in changing their operational procedures.

4 Valuing the economic benefits

The aim of this study is to evaluate the net benefits directly attributable to the research activities undertaken in the two projects. The assessment is limited to the three irrigation schemes that were directly affected by the research. Research results may be adapted to improve water management in other irrigation areas. However, there was no evidence of further applications at the time of the evaluation and they were not considered as an outcome of the ACIAR research.

The time horizon for estimating the benefits of both projects is 30 years. ACIAR funding of the projects commenced in January 1995 with an investigation of the operational performance of the La Khe irrigation scheme. This project was completed in December 1998 and the results were partially applied to water-scheduling decisions in the 1998–99 spring cropping season:

- the evaluation period is from 1994–95 through to 2023–24
- project benefits begin to accrue in the 1998–99 season.

The second project began in January 1999 with the adaptation of the same methodology to the irrigation schemes in Dan Hoai and Cu Chi. This project was completed in December 2003. The results were partially applied to water-management decisions in the 2003–04 winter/spring season at Ch Chi and the 2003–04 spring season at Dan Hoai.

Project benefits are evaluated separately for each irrigation scheme. Valuation of the benefits required various assumptions on the applied impact of the research. The assumptions were based on discussions with the management of irrigation companies and research personnel in Vietnam and Australia. This information was supplemented by a review of several research papers.

Based on advice from the project leaders, meetings were held with the managers of the La Khe and Cu Chi irrigation schemes. There were no discussions with the managers of the Dan Hoai scheme and data on the applied impact of the research were not provided. Water-management issues affecting the Dan Hoai scheme were similar to those experienced in the La Khe scheme:

- the research the evaluation of the Dan Hoai project was based on the methodology and assumptions used for the La Khe scheme.

Issues in valuing the project benefits

Economic benefits begin to accrue when the respective irrigation companies apply the research results to their operational rules and water deliveries schedules. Adoption of research results is often a gradual process. The response of the irrigation companies reflected a conservative approach to applying the research recommendations on seasonal water flows:

- the managers of the La Khe scheme indicated the operational recommendations were fully applied after 6 years in 2003–04
- the managers of the Cu Chi scheme suggested there would be a 3–5 year delay before the recommendations would be fully adopted.

A component of the ACIAR research involved the development of new institutional arrangements for water users. Institutional reform was expected to make a contribution towards improvements in water management. The research included proposals to develop water-user groups and changes in the water-charging mechanism. The economic benefits of this research were dependent on the adoption of volume-based pricing to encourage water-use efficiencies by farmers.

A shift to a volume-based pricing mechanism would involve a fundamental policy reform. This change has not occurred. While the proposals have merit there is no indication that a change will occur in the foreseeable future. Consequently, this evaluation has assumed there is no adoption of this aspect of the research:

- if a policy change were to occur at a later date, the benefits would need to be spread over a range of research projects and policy advice
- a small amount of the benefits may be attributable to the ACIAR projects.

Another component of the ACIAR projects involved assessments of the financial viability of the irrigation companies that managed the three schemes. The research revealed the extent of revenue shortfalls and the dependence on government subsidies. It demonstrated the lack of provisioning for infrastructure maintenance and depreciation.

This aspect of the project has not contributed to the economic benefits of the ACIAR research. There is no indication that irrigation fees will be increased to improve the stand-alone viability of the irrigation companies. Were this to occur, it would involve a financial transfer between public subsidies and the user-pay mechanism. This does not constitute an economic benefit for the project evaluation.

The evaluation values farm-level benefits in terms of changes in crop outputs. The changes are valued at the 'economic price' of the outputs. Subsidies, taxes and market-support measures can distort the price received by farmers, which may not be a good reflection of the economic value of the output. In these circumstances, shadow prices should be used to value the project benefits.

The central government provides support for the maize industry. It provides financial assistance for the production of hybrid seed and uses trade policies to support market returns. In the past, licences were used to control imports but these were abolished in April 2000 (USDA 2000). Since then the market has been supported by tariff protection which affects the price of domestically produced maize through competition with imports:

- the maize tariff has a preferential rate of 5% and a general rate of 7.5% (USDA 2004).

These support measures create distortions in the domestic price. A shadow price of maize was estimated and used to value the farm-level benefits. In 2003–04, the US export price of maize was US$115/tonne. This is a reasonable indicator of an undistorted world price of maize. An equivalent farm-gate price in Vietnam requires a discount of around 15% for transport and handling costs. This suggests a shadow price of maize of US$98/tonne—equivalent to 1,528 VND/kg (Table 2).

Tariff protection is also provided for peanuts at a preferential rate of 10% and a general rate of 15%, but the tariff is not a binding policy instrument. There are no imports and the industry exports around 30% of total output (USDA 2003). There are no government support programs for the industry and market prices are not distorted by policy interventions. The domestic price has therefore been used to value the economic benefits from peanut yield improvements.

Table 2. Crop prices used to value the improvement in farm performance

Year ended October	Rice[a]		Peanuts[a]		Maize[b]	
	VND/kg	% change	VND/kg	% change	VND/kg	% change
2001–02	1,800	–	6,000	–	1,149	–
2002–03	1,800	0.0	6,500	8.3	1,404	22.2
2003–04	1,900	5.6	7,000	16.7	1,528	33.0

[a] Domestic price received by farmers.

[b] Shadow price based on US export price of no. 2 yellow corn (fob, Gulf ports) adjusted for transport and handling costs.

Sources: ABARE (2004); ADB (2005); La Khe Irrigation Company; Cu Chi Water Company.

Vietnam's rice market gains import protection through a preferential tariff of 40% (USDA 2001). However, the import tariff is not a binding policy instrument. Vietnam is the world's third largest export supplier on world markets and the fluctuations in farm returns are primarily determined by changes in global market developments.

In the past, rice export quotas have been specified to ensure there are adequate rice supplies for the domestic market. Binding export quotas could potentially distort market returns, but in recent years the quotas have not been a constraint on sales. For this reason the domestic price has been used to value the economic benefits from improved rice yields.

The ACIAR research indicates there are project benefits in the form of reduced water-pumping costs. The issue of distortions in electricity pricing was considered but it was not possible to determine if subsidies reduce the cost paid by the irrigation companies. Accordingly, the evaluation used the market price of electricity to value these benefits.

Project benefits for the La Khe irrigation scheme

Research activities for the La Khe irrigation scheme led to the development of new operational rules within the existing infrastructure constraints (Turral et al. 2002). The research was conducted with the cooperation of the La Khe Irrigation Company (LKIC). Major research activities involved:

- hydraulic assessments of the existing system infrastructure
- monitoring the pre-existing operational performance in terms of water distribution and the adequacy of water supplies for crop demands
- the development of a model to determine the efficiency and effectiveness of water allocations under alternative operational rules
- field trials of alternative operational rules
- the specification of management structures for water user associations (WUAs) and proposals for alternative charging mechanisms for water fees.

An assessment of pre-existing operational performance was conducted for the 1996–97 spring season. It showed the system as a whole was supplied with 42% more water than was required to meet the estimated demand. The assessment also confirmed there was a wide disparity in the distribution of water across the system.

In the upper reaches of the system, the two major secondary canals were substantially oversupplied. The lower reaches of the system were substantially undersupplied, receiving less than 60% of their water requirements (Table 3). The LKIC adjusted its pumping schedules for the 1997–98 spring season. A subsequent assessment showed water supplies for the whole system were approximately equal to the estimated demand:

- the upper reaches of the system were undersupplied, but the lower reaches continued to experience a substantial water deficiency

Table 3. Performance assessment of water distribution in the La Khe scheme[a]

	Water supply/demand ratio					
	Spring 1997		Spring 1998		Summer 1998	
	ratio	% deficiency	ratio	% deficiency	ratio	% deficiency
Whole system	1.42	42.0	0.91	−9.0	0.98	−2.0
Upper reaches[b]	1.44	43.8	0.64	−35.8	0.77	−23.4
Lower reaches[c]	0.58	−42.0	0.61	−39.3	0.78	−21.9

a Seasonally corrected ratio of actual water supplied and simulated irrigation demand. Based on water flow monitoring at different points of the system—a ratio of less than 1 indicates a water deficiency.

b Average ratio for the N1, Reach 2, N1a, N3 and N5 service areas—average of available data.

c Average ratio for the Lower CA, N5b, N9, Reach 4, N13, Reach 5, N13a, N13b, N15a and N15b service areas—average of available data.

Source: Turral et al. (2002)

- this demonstrated the limitations of the infrastructure and the water losses from surface drainage and illegal off-take.

A field trial of new operational rules involving a rotational water-supply schedule was conducted for the spring cropping season of 1998. It showed that a more equitable distribution of water could be achieved if the lower reaches of the system were supplied first. However, it also showed that parts of the system would remain undersupplied.

Applying the research to the La Khe scheme

The trial results encouraged the LKIC to adopt new operating procedures and to make some infrastructure improvements to achieve greater distributional efficiencies. Water user advisory committees (WUACs) were established in parts of the system and detailed operational rules were established. Partial adoption of the revised operating procedures commenced in the 1998–99 spring season.

The benefits of improved water management can be attributed to the ACIAR research. The pre-existing performance assessment, trial results, application of the IMSOP model and change in operating procedures all contributed to the management changes by the company. The LKIC indicated the ACIAR project was the only source of research advice for the changes that were implemented:

- any benefits from the implementation of alternative operating rules can be wholly attributed to the ACIAR research activities.

The application of the ACIAR research involved some company expenditures on infrastructure maintenance and development. These expenditures are an implementation cost in the project evaluation. It was not possible to obtain an estimate of new expenditures and the evaluation does not account for this aspect of applying the research results:

- these expenditures appear to be a relatively small, one-off expense
- the evaluation may be marginally overestimated by excluding this effect.

Application of the research does not generate an optimal system-wide water distribution in all areas serviced by the scheme. It leads to an improvement but does not achieve a water supply and demand balance in all parts of the system. Infrastructure deficiencies prevent this from occurring.

Over time there may be further gains in water-management efficiency that could reduce operating costs and increase crop yields. This will require expenditures on infrastructure improvements, maintenance and off-take compliance monitoring. No information was available on the potential cost of these sorts of developments and the evaluation does not consider any gains from future physical changes to the irrigation system:

- benefits from physical changes would need to be evaluated against the required infrastructure expenditures
- a portion of any potential net gains may be attributable to the ACIAR project.

Valuing the La Khe benefits

The LKIC managers indicated that new operational rules were not immediately applied in full. The 2003–04 spring season was the first time the recommended changes in the pumping schedule were fully applied. Therefore, the project benefits were based on an assumed time path of adoption over the 1998–99 to 2003–04 period.

The LKIC assessed the changes in system performance that occurred as a result of adopting the new operational rules. Two benefits were identified:

- improved crop yields from a closer alignment of water supplies to crop demands in areas that had previously experienced a water deficiency
- reduced pumping costs to service the spring crop demand requirements.

An important benefit of applying new operational rules is that crop yields rise because of reduced water stress over much of the irrigation system. The change in water applications and pumping schedules affects output from the spring season crop:

- changes in water application in the summer season are highly uncertain because of the variability in rainfall and a requirement for water drainage services

- project benefits are estimated for spring season outcomes—no benefits have been assessed for the summer season.

Most of the benefit would be obtained by farms in the middle and lower reaches of the system. There were no field trials to establish the extent of the yield gains from a water distribution that matched water supplies and demand. The LKIC was also unable to provide data on the size of the reduction in water deficiencies in different parts of the system.

This required a number of assumptions about the type of changes that occurred. For the purposes of the evaluation, it was assumed that rice was the only crop grown in the spring season. This is not an unreasonable assumption as crop diversification mostly occurs in the winter season. The LKIC management also indicated that the spring crop mostly involves rice production.

Data supplied by the LKIC suggest there has been a small improvement in spring season rice yields since the revised operational rules were implemented in 1998–99:

- average rice yields across the system were estimated at 6.1 t/ha in spring 2003–04
- in 1997–98 the average rice yield was 5.6 t/ha
- 2001–02 was the first year that significant yield changes were observed.

The LKIC indicated the 0.5 t/ha increase in yields by 2003–04 was most likely due to improved water management and is attributable to the ACIAR project. However, a number of factors, such as fertiliser use, can affect crop yields apart from the supply of water. While recognising that other factors can influence yields it is likely that the change in water application rates has been an important factor in this yield growth:

- in taking a conservative approach to the project impact it was assumed 80% of the observed yield growth was the benefit from changing operational procedures.

In the absence of supporting evidence from field trials, it was assumed a 0.4 t/ha improvement in yields was the maximum, *system-wide effect* from implementing the project recommendations. It was further assumed this was a gradual yield improvement in the period leading up to the 2003–04 spring season. This reflects that fact that the change in operating procedures was not fully applied until 2003–04.

Implementing the project results would not have had much effect on yield performance in the upper reaches of the system. Water was oversupplied or close to satisfying estimated crop demands in areas closest to the pumping station. Therefore, the project impact on average yields across the entire system would be diluted by the non-response in these areas.

The extent and distribution of the pre-existing water deficiencies suggests there would be widespread gains in average crop yields (see Table 3). It seems likely that at least two thirds of the farms attached to the system would have gained a statistically significant yield benefit. The size of the benefit would vary according to the extent of the improvement in water supplies:

- the 0.4 t/ha *system-wide change* in average yields would imply a yield effect of about 0.6 t/ha for the two-thirds of farms that gained a more reliable water supply.

A change of this magnitude is not unrealistic in the context of 2000 survey information that examined farm performance in different parts of the system (Marsh et al. 2003). The difference in average spring rice yields between farms at the top and bottom of the N5 secondary canal was reported to be around 0.6 t/ha. Therefore, the evaluation assumed:

- a project benefit equivalent to a 0.6 t/ha increase in rice yields—in the absence of verifying information a conservative approach was taken for this assumption
- this benefit is an average effect obtained by farms in the (assumed) two-thirds of the crop area that was utilised in the spring season.

The total irrigated area in the La Khe system is 8,650 ha. While there is the potential for all farms to grow three crops per year this does not currently occur: some farms are growing only two crops per year. As the entire system grows rice in the summer wet season this means a portion of the irrigation area is not used in the winter and spring cultivation seasons.

The LKIC was unable to provide estimates of any changes in non-irrigation costs or the irrigation area that was used for spring season crops. However, the system managers confirmed that a portion of the irrigation area is not utilised in the spring season. For the purposes of the evaluation it was assumed the spring season crop used two-thirds of the total irrigation area:

- to the extent this assumption under- (over-) estimates the irrigation area used in spring the evaluation will tend to understate (overstate) the project benefits
- estimates of the crop yield benefits are provided in Table 4.

A second benefit was identified as the reduction in the amount of water supplied to the system in the spring season. This was achieved by gaining a more even distribution of water across the system. It was also due to management efforts to reduce 'losses' by improving infrastructure performance (e.g. operation of gates, monitoring of 'unauthorised' water use).

This benefit can be attributed to the application of the project results because it was a necessary requirement of implementing the revised operating rules. In the 1997–98 spring season, the LKIC supplied 54.8 million m^3 (MCM) of water to the system (Turral et al. 2002). By 1999–2000 the estimated reduction in spring water use was reported to be 4.6 MCM.

The LKIC indicated that when the new rules were fully implemented there was a net reduction in water use of around 17% when compared to the pumping schedule in the 1997–98 spring season. This is equivalent to water savings of around 9.3 MCM in the 2003–04 spring season. It assumes the 54.8 MCM would have continued to apply in the absence of the revised operating rules:

Table 4. Project benefits from changes in spring yields, La Khe[a]

Year ended October	Total crop area[b] (ha)	Change in rice yield (t/ha)	Change in rice production[c] (tonnes)	Price of rice (VND/kg)	Project benefits[d]	
					(million VND)	(A$'000)
1997–98	5,709	0.0	0	1,700	0	0
1998–99	5,709	0.1	377	1,700	641	74
1999–00	5,709	0.2	754	1,750	1,319	153
2000–01	5,709	0.3	1,130	1,750	1,978	250
2001–02	5,709	0.4	1,507	1,800	2,713	341
2002–03	5,709	0.5	1,884	1,800	3,391	368
2003–04	5 709	0.6	2,261	1,900	4,295	395
2004–05	5,709	0.6	2,261	1,900	4,295	365
2005–06	5,709	0.6	2,261	1,900	4,295	365
2007–24	5,709	0.6	2,261	1,900	4,295	365

a Effect of improved water distribution from adopting ACIAR project outcomes.

b Spring cropping area is assumed to be two-thirds of the total irrigation area. Cropping area is assumed to remain unchanged over the evaluation period and is used for rice production.

c Yield improvement is assumed to apply to 66% of the spring crop area—some farms did not experience water deficits under the pre-existing operating procedures. Maximum yield effect assumed to occur in 2003–04 with full adoption of the revised operating procedures.

d Crop output valued at domestic market price for rice. Assumes no change in non-irrigation costs—data unavailable. Benefits from 2004–05 converted to Australian dollars at A$1 = 11,770 VND—actual exchange rates were used before 2004–05.

Source: La Khe Irrigation Company.

- to the extent this assumption under- (over-) estimates the spring season water saving, the evaluation will tend to understate (overstate) the project benefits.

The economic value of this benefit is estimated from the lower energy cost to pump water into the system. It is an efficiency gain from improved water management. The 2003–04 estimate reflects the maximum reduction in water use from applying the project research results. A time path of estimated water savings was calibrated to the LKIC estimates provided for 1999–2000 and 2003–04 (Table 5).

Data supplied by the LKIC indicated electricity costs were 660 VND/kW hour in 1998–99. After adjusting for the water-delivery rate of the main pumping station this was equivalent to an average pumping cost of about 17 VND/m^3. The cost of electricity increased by 14% in 2001–02 but has remained constant since then. This was equivalent to an average pumping cost of about 19 VND/m^3 in 2001–02.

The combined benefits of applying the research results to the La Khe irrigation system were estimated at A$380,000 in 2003–04. This involved a A$365,000 gain from improved crop yields and a A$15,000 benefit from the reduction in irrigation servicing costs. Annual project benefits were limited in the initial stages of implementing the research but increased when the LKIC fully adopted the recommended water-scheduling rules.

Project benefits for the Dan Hoai irrigation scheme

Research activities for the Dan Hoai scheme involved the development of new operational rules within the existing infrastructure constraints (George et al. 2004). The research was conducted with the cooperation of the Dan Hoai Irrigation Company (DHIC). Major research activities involved:

Table 5. Project benefits from changes in system water supplies, La Khe[a]

Year ended October	Irrigation area[b] (ha)	Change in water supply (million m^3)	Electricity cost VND/ kW (hour)	Pumping cost[c] (VND/m^3)	Project benefits[d]	
					(million VND)	(A$'000)
1997–98	5,709	0.0	660	17	0	0
1998–99	5,709	–2.3	660	17	38	4
1999–00	5,709	–4.6	660	17	76	9
2000–01	5,709	–5.8	660	17	95	12
2001–02	5,709	–7.0	750	19	130	16
2002–03	5,709	–8.1	750	19	152	17
2003–04	5,709	–9.3	750	19	174	16
2004–05	5,709	–9.3	750	19	174	15
2005–06	5,709	–9.3	750	19	174	15
2007–24	5,709	–9.3	750	19	174	15

a Effect of reducing water supplied to the irrigation system from adopting ACIAR project outcomes.
b Spring cropping area is assumed to be two-thirds of the total irrigation area.
c Cost based on water delivery rate for main pumping system (39.99 m^3 per kW hour).
d Water saving valued at the cost of pumping water into the system. Assumes no change in non-irrigation costs—data unavailable. Benefits from 2004–05 converted to Australian dollars at A$1 = 11,770 VND—actual exchange rates were used before 2004–05.
Source: La Khe Irrigation Company.

- hydraulic assessments of the existing system infrastructure
- the development of a model to determine the effectiveness of water allocations under various operational rules
- monitoring and evaluation of the pre-existing operational performance in terms of water distribution and the adequacy of water supplies for crop demands
- field trials of alternative operational rules.

An assessment of pre-existing operational performance was conducted for the 1999–2000 spring season. It showed the system as a whole experienced a water-supply deficiency of around 15%. The DHIC supplied 40.9 MCM of water for a model-estimated crop demand of 48.0 MCM. The assessment also confirmed there was an uneven distribution of water across the system.

Project reports indicate all reaches of the system had water deficiencies, including those closest to the pumping station (Table 6). The DHIC adjusted pumping schedules in the 2000–01 spring season and water supplies at the pumping station were equivalent to the estimated crop demand. However, a subsequent assessment showed water-supply deficiencies over much of the system:

- the upper reaches of the system closest to the pumping station and the Ba Giang sluice gate experienced an oversupply of water
- the remainder of the system experienced a 16% water deficiency.

This spring 2000–01 system performance demonstrated the limitations of the infrastructure. A significant amount of water was 'lost' to the system due to illegal off-take, limitations in channel capacity and operating problems with water off-take gates. A further retrospective performance assessment in the spring of 2001–02 found the entire system was again undersupplied with water.

The IMSOP model was used to simulate the system performance for three alternative operational rules. The analysis showed there was insufficient capacity in the main canal to meet peak water demand if the system was operated continuously. It also revealed that there were operational problems with many of the off-take structures and that the pumping stations had insufficient capacity to the meet peak water demands under a system-wide rotational supply schedule.

A field trial of new operational rules was conducted for the spring cropping season of 2002–03. It showed a more equitable distribution of water could be achieved if the secondary canals and off-takes were operated under a rotational schedule. The trial demonstrated water supplies would exceed demand at all monitoring points.

Applying the research to the Dan Hoai scheme

The trial results encouraged the DHIC to adopt new operating rules. Project research managers indicated the new rules were partially adopted for the spring season

Table 6. Performance assessment of water distribution for the Dan Hoai scheme[a]

	Water supply/demand ratio					
	Spring 2000		Spring 2001		Spring 2002	
	ratio	% deficiency	ratio	% deficiency	ratio	% deficiency
Whole system	0.84	–16.0	0.97	–3.0	0.84	–16.0
Upper reaches[b]	0.86	–14.5	1.16	16.0	0.76	–24.0
Lower reaches[c]	0.84	–16.3	0.84	–16.0	0.87	–13.0

a Seasonally corrected ratio of actual water supplied and simulated irrigation demand. Based on water flow monitoring at different points of the system—a ratio of less than 1 indicates a water deficiency.

b Average ratio for the pumping station and N2 (Ba Giang sluice gate) service areas—average of available data.

c Average ratio for the Minh Khai, N1 N11 service areas—average of available data.

Source: George et al. (2004).

of 2003–04. There was no information available on the effects of applying the new rules. The project evaluation for the Dan Hoai scheme was therefore based on the assumptions and outcomes that were used to evaluate the benefits obtained for the La Khe scheme:

- the evaluation assumed an adoption period of 6 years, with the revised operational rules fully applied in the 2008–09 spring season.

The benefits of improved water management by the DHIC can be attributed to the ACIAR research. The pre-existing performance assessment, trial results, application of the IMSOP model and change in operating procedures all contributed to the adjustments adopted by the company. There was no indication of other research advice contributing to the management changes.

The application of the ACIAR research could involve some company expenditures on infrastructure maintenance to improve the performance of off-take structures and to remove illegal outlets. These expenditures would be an implementation cost in the project evaluation but it was not possible to obtain an estimate of planned expenditures:

- the evaluation does not account for these potential expenditures, which are likely to be a relatively small, one-off expense
- the evaluation may be marginally overestimated by excluding this effect.

Valuing the Dan Hoai benefits

Adoption of the new operational rules will lead to improved spring-season crop yields from a closer alignment of water supplies to crop demands. The expectation of this benefit is based on outcomes for the La Khe irrigation scheme. For the purposes of the evaluation, it was assumed rice is the only crop grown in the spring. This is a reasonable assumption as crop diversification has occurred mostly in the winter season.

The trial results suggest that application of the research could generate a system-wide equitable water distribution. Water supply could equal or exceed crop demands in all service areas once the revised rules were fully implemented. This would imply there are no infrastructure deficiencies to prevent this from occurring.

An optimal water distribution in all service areas would lead to a system-wide improvement in crop yields. The pre-existing performance assessment indicated that all service areas experienced a water deficiency. However, a more conservative assumption was used in the evaluation because of the infrastructure maintenance issues that were identified during the research:

- it was assumed yield benefits from the project would occur in 75% of the system.

A point of difference with the La Khe system is that the issue affecting the Dan Hoai scheme is a system-wide deficiency in water supply. There was no indication in the research that the revised operating procedures would reduce the amount of water supplied to the system. As the research has only recently been applied, there is insufficient information to determine if the new operating procedures could lead to higher or lower total water supplies.

Future monitoring of the applied effects of new operating results will be necessary to determine if there is an impact on pumping costs in the Dan Hoai scheme. Given the uncertainty on the impact for water supplies it was assumed the revised operating rules would not generate gains (losses) for the DHIC in the form of lower (higher) pumping costs.

There were no field trials to establish the extent of the yield gains from a water distribution that matched supply with estimated demand. It was assumed there would be a 0.6 t/ha gain in rice yields from applying the revised operating rules. This was the maximum effect and there would be a gradual yield improvement in the period leading up to the 2008–09 spring season:

- this benefit is an average effect obtained by farms in three-quarters of the crop area that was utilised in the spring season.
- these assumptions are consistent with the valuations for the La Khe scheme.

The total irrigated area in the Dan Hoai system is 6,520 ha. While there is the potential for all farms to grow three crops per year this currently does not occur. Some farms are cultivating only two crops per year. As the entire system grows rice in the summer wet season this means a portion of the irrigation area is not used in the winter and spring cultivation seasons.

Estimates of the Dan Hoai irrigation area that was used for spring-season crops were unavailable. However, cropping patterns in the Dan Hoai scheme are likely to be similar to those in the La Khe scheme. Therefore, the evaluation assumed the spring-season crop used two-thirds of the total irrigation area:

- the expected benefits of applying the research results to the Dan Hoai irrigation system were estimated at A$313,000 in 2008–09 (Table 7).
- to the extent this assumption under- (over-) estimates the irrigation area used in spring the evaluation will tend to understate (overstate) the project benefits.

Project benefits for the Cu Chi irrigation scheme

Research activities for the Cu Chi scheme involved the development of new operational rules to improve water management (George et al. 2003). The research was conducted with the cooperation of the Cu Chi Water Company (CCWC). Major research activities were similar to those undertaken for the other schemes. The only significant difference was the project included field trials to establish the crop-yield gains from a change in operating rules.

An IMSOP model of the Cu Chi scheme was used to assess the operational performance of the system. The analysis was carried out for all three cropping seasons in 2001–02 and for the winter/spring season of 2002–03. The results showed a consistent pattern of excess supply in each season. The assessment also confirmed there were substantial inequities in the distribution of water supplies across the scheme.

Table 7. Project benefits from changes in spring rice yields, Dan Hoi[a]

Year ended October	Total crop area[b] (ha)	Change in rice yield (t/ha)	Change in rice production[c] (tonnes)	Price of rice (VND/kg)	Project benefits[d]	
					(million VND)	(A$'000)
2002–03	4,303	0.0	0	1,800	0	0
2003–04	4,303	0.1	323	1,900	613	56
2004–05	4,303	0.2	645	1,900	1,226	104
2005–06	4,303	0.3	968	1,900	1,840	156
2006–07	4,303	0.4	1,291	1,900	2,453	208
2007–08	4,303	0.5	1,614	1,900	3,066	260
2008–09	4,303	0.6	1,936	1,900	3,679	313
2009–10	4,303	0.6	1,936	1,900	3,679	313
2011–24	4,303	0.6	1,936	1,900	3,679	313

a Effect of improved water distribution from adopting ACIAR project outcomes.

b Spring cropping area is assumed to be two-thirds of the total irrigation area. Cropping area is assumed to remain unchanged over the evaluation period and is used for rice production.

c Yield gain equivalent to observed effect in the La Khe scheme—assumed to apply to 75% of the impact area. Maximum yield effect assumed to occur in 2008–09 with full adoption of the revised operating rules.

d Crop output valued at domestic market price for rice. Assumes no change in non-irrigation costs—data unavailable. Benefits from 2004–05 converted to Australian dollars at A$1 = 11,770 VND—actual exchange rates were used before 2004-05.

Source: La Khe Irrigation Company.

While the analysis revealed significant differences in the water supply and demand balance in each of the service areas, there was no consistent pattern (George et al. 2003). Water was oversupplied in most of the service areas in each of the cropping seasons. Some service areas experienced a water deficiency in one season followed by an oversupply in another season.

In general, the system was supplying too much water for optimal crop-growing conditions. During 2001–02 the excess supply of water was estimated at 119.5 MCM. In the 2002–03 winter/spring season the excess supply of water was 62 MCM. The average water-supply/demand ratios were:

- 1.68 in the 2001–02 winter/spring season
- 1.89 in the 2001–02 summer/autumn season
- 1.72 in the 2001–02 main (monsoon) crop season
- 2.51 in the 2002–03 winter/spring season.

The CCWC purchases water from the government agency that manages the Dau Tieng Reservoir. It pays for access rights to a specified flow of water that supplies the irrigation system by gravity. The pre-existing operational rules involved maintaining a constant water-flow in the major canals, but the lack of flow-regulating structures created problems for managing water allocations to individual service areas.

The performance assessment indicated that the system was managed without proper regard to the water demands for individual crops. In some areas, the constant oversupply of water affected crop yields because the land was waterlogged. This was especially evident in the winter/spring season when there were opportunities to diversify into dryland crops. The water-management problem was amplified if the irrigation system was operating during periods of rainfall.

A model-based analysis of alternative operational rules considered the system performance under continuous- and rotational-flow schedules. The alternatives were tested with field trials that showed the scheme could operate with less water. It also showed a more equitable distribution of water could be achieved:

- the average water supply/demand ratio could be reduced to around 1.2, which would reduce the problem of waterlogged land throughout the system.

Applying the research to the Cu Chi scheme

The trial results encouraged the CCWC to change its operating rules. New rules were partially adopted for the winter/spring season of 2003–04. CCWC managers expected the recommended water-supply schedule would be fully adopted in 3–5 years. The evaluation assumed an adoption period of 5 years, with the revised rules fully applied in the 2007–08 crop year.

The benefits from improved water management by the CCWC can be attributed to the ACIAR research. The pre-existing performance assessment, trial results, application of the IMSOP model and change in operating procedures all contributed to the changes adopted by the company. There was no indication of other research advice contributing to the management changes.

Application of the ACIAR research could lead to new expenditures on infrastructure maintenance and development that would improve system performance. These expenditures would be an implementation cost in the project evaluation, but estimates of their size were unavailable. The evaluation may be marginally overestimated by excluding this effect.

Application of the research does not generate an optimal system-wide water distribution in all areas serviced by the scheme. It reduces the amount of excess water supplied to the system, but it does not achieve a water supply and demand balance in all parts of the system. Infrastructure deficiencies prevent this from occurring.

Valuing the Cu Chi benefits

Adoption of the new operational rules will generate benefits from a reduction in the amount of water supplied to the system. The CCWC identified two benefits:

- improved crop yields in areas that had problems with waterlogged land
- reduced water usage by the system.

The main impact was expected to occur in the winter/spring cropping season when waterlogging was an important issue for farm performance. The CCWC was able to provide some useful information on the changes in water use and farm performance in the initial stages of adopting the new operating rules (Table 8). This information contributed to the valuation of the project benefits.

The area used for cropping in the winter/spring season is considerably less than the total drainage area of the system. Company managers indicated this reflected problems with waterlogged land in some service areas, but they also said that a portion of the irrigation area is not used in the winter/spring season. The evaluation took a conservative approach on specifying the project impact area and assumed crop areas remained unchanged after 2004–05 at 5,632 ha:

- to the extent that this assumption under- (over-) estimates the area used in the winter/spring season the evaluation will tend to understate (overstate) the project benefits.

A component of the project involved field trials to establish the impact on crop yields of changing the water application. The CCWC provided results of the field trials for the major crops grown in the winter/spring season (Table 9). This information was used to establish the size of the yield improvement that could be achieved:

- these estimates were assumed to be the maximum, system-wide effect in 2007–08
- a time path of gradual yield improvements was imposed in the intervening period.

The Cu Chi system also supplies irrigation water in the summer/autumn season. The assessment of system performance under the pre-existing rules showed a substantial excess supply of water in most service areas (George et al. 2003). A change in the operational rules is therefore also likely to affect crop yields in this period and provide additional project benefits.

The evaluation assumed rice is the only crop grown in the summer/autumn season. This is a reasonable assumption as crop diversification generally occurs in the winter/spring season. As there were no field trials to assess the effect on summer rice yields, the assumption used for the winter/spring evaluation was used to value these benefits.

Information on seasonal cropping areas provided by the CCWC indicates a sizeable portion of the irrigation area is not used in the summer/autumn season. In 2003–04, around 3,340 ha of the total drainage area was used during this period. This suggests that some farmers do not produce three crops per year. The evaluation

Table 8. Winter/spring farm performance in the Cu Chi irrigation system

Year ended October	Rice	Peanuts	Maize	Other[a]	Total
2002–03[b]					
Irrigated crop area (ha)	3,835	895	764	742	6,236
area utilised[c] (%)	26.4	6.2	5.3	5.1	43.0
Average yield (t/ha)	4.1	2.4	6.0	–	–
2003–04[d]					
Irrigated crop area (ha)	3,451	1,064	758	765	6,038
area utilised[c] (%)	23.8	7.3	5.2	5.3	41.6
Average yield (t/ha)	3.9	3.3	6.6	–	–
2004–05[d]					
Irrigated crop area (ha)	2,961	1,120	767	784	5,632
area utilised[c] (%)	20.4	7.7	5.3	5.4	38.8
Average yield (t/ha)	na	na	na	–	–

[a] Includes fruit and aquaculture.
[b] Water application rate based on pre-existing operating procedures.
[c] Proportion of total drainage area (14,500 ha) utilised in the winter/spring season.
[d] Water application rate based on partial adoption of operating procedures based on ACIAR project outcomes.
Source: Cu Chi Water Company.

adopted a conservative approach to specifying the project impact area and assumed the summer crop area remained unchanged after 2003–04:

- to the extent this assumption under- (over-) estimates the area used in the winter/spring season the evaluation will tend to understate (overstate) the project benefits.

Improved water management in all service areas would lead higher crop yields throughout the system. The performance assessment indicated that most service areas had an excess water supply under the pre-existing operational rules. A more-conservative assumption was used in the evaluation as some service areas did not experience a significant water deficit or excess supply:

- it was assumed the yield benefits are achieved by 75% of the system in both seasons
- estimates of the crop yield benefits are provided in Tables 10 and 11.

A second project benefit was the reduction in water supplied to the system in both seasons. This benefit can be attributed to the application of the project results, because it was an outcome of implementing the revised operating rules. The CCWC provided data on the amount of water supplied to the system in both seasons. This information was used to estimate the change in water use from applying the new operating rules.

The CCWC supplied 198 MCM of water to the system in the winter/spring and summer/autumn seasons in 2002–03 (Table 12). The combined irrigation area utilised in the two seasons was 10,633 ha. This was equivalent to an application rate of 19,000 m^3 of water per ha under the pre-existing operational rules.

The IMSOP model estimated the crop demand for water in 2002–03 was 164 MCM. This indicated the system had an excess water supply of 34 MCM. In 2003–04, revised operating rules were partially applied for the first time. Cropping areas declined to 9,378 ha and the assessment of system performance showed the excess water supply declined marginally to 32 MCM.

An estimate of the benefits of reducing the amount of water supplied to the system required a number of assumptions. CCWC estimates of water demand in 2003–04 suggest an application rate of 13,000 m^3 of water per ha under the new operational rules (Table 12). The evaluation assumed this would be the application rate achieved when the rules were fully adopted in 2007–08.

This assumption implies the area allocated to different crops in the winter/spring season remains unchanged over the evaluation period. The same assumption was used to value the yield benefits. A time path of gradual reductions in water application rates was developed to reflect the 5-year adoption period (Table 13).

Table 9. Cu Chi trial results for crop yields from revised operating rules[a]

Year ended October	Rice yield		Peanut yield		Maize yield	
	t/ha	change from 2001–02	t/ha	change from 2001–02	t/ha	change from 2001–02
2001–02[b]	3.3	–	2.8	–	4.7	–
2002–03[c]	3.3	0.0	2.5	−0.3	4.6	−0.1
2003–04[c]	3.9	0.5	3.2	0.4	5.0	0.4
Estimated impact	0.5	–	0.4	–	0.4	–

[a] Results of CCWC pilot study for 150 farms in the winter/spring cropping season. Crop yields in 2002–03 were affected by poor growing conditions due to unusually high rainfall.

[b] Water application rate based on pre-existing operating procedures.

[c] Water application rate based on full adoption of operating procedures based on ACIAR project outcomes.

Source: Cu Chi Water Company.

Estimates of water supplied to the system were derived from the assumed water-application rates and the combined crop areas for the two seasons. The reduction in water use was estimated as the difference from the amount of water supplied under the 2002–03 application rate of 19,000 m^3 per ha. This was the water application rate under the pre-existing operational rules.

The CCWC water-supply agreement with the manager of the reservoir involves a fixed fee for a maximum flow of water into the system. The opportunity to use the water savings to reduce bulk-water costs is limited without a renegotiation of the agreement. However, the CCWC indicated there was an opportunity to on-sell surplus water to the Ho Chi Minh City municipal government for industrial and household water use:

- the irrigation scheme is linked to the water supply system for Ho Chi Minh City.

Valuation of the water-saving benefits should be based on the 'economic cost' of water. In the absence of a market-determined price, the valuation could use an estimate of the shadow price of water. However, estimating a realistic shadow price was, because of data limitations, beyond the scope of this evaluation.

An alternative approach to valuing these benefits is to use the opportunity cost of an alternative use of the water. The Ho Chi Minh City municipal government is willing to purchase water from the managers of the Cu Chi scheme to supplement its existing supplies. The CCWC indicated the municipal government would purchase untreated water for 250 VND per cubic meter. This price was used to value the benefits of reduced water use across the irrigation scheme:

- to the extent this assumption under- (over-) estimates the economic cost of water the evaluation will tend to understate (overstate) the project benefits.

Table 10. Project benefits from changes in winter/spring crop yields, Cu Chi[a]

Year ended October	Total crop area[b] (ha)	Rice crop		Peanut crop		Maize crop		Project benefits[d]	
		area (ha)	change in yield[c] (t/ha)	area (ha)	change in yield[c] (t/ha)	area (ha)	change in yield[c] (t/ha)	million VND	A$'000
2002–03	6,236	3,835	0.0	895	0.0	764	0.0	0	0
2003–04	6,038	3,451	0.1	1,064	0.1	758	0.1	1,137	105
2004–05	5,632	2,961	0.2	1,120	0.2	767	0.2	2,196	187
2005–06	5,632	2,961	0.3	1,120	0.2	767	0.2	2,618	222
2006–07	5,632	2,961	0.4	1,120	0.3	767	0.3	3,715	316
2007–08	5,632	2,961	0.5	1,120	0.4	767	0.4	4,813	409
2008–09	5,632	2,961	0.5	1,120	0.4	767	0.4	4,813	409
2009–10	5,632	2,961	0.5	1,120	0.4	767	0.4	4,813	409
2011–24	5,632	2,961	0.5	1,120	0.4	767	0.4	4,813	409

a Effect of improved water distribution from adopting ACIAR project outcomes.

b Winter/spring cropping areas are assumed to remain unchanged from 2004–05 plantings.

c Yield improvement is assumed to apply to 75% of the impact area—some farms did not experience significant water deficits or excess water applications under the pre-existing operating procedures. Maximum yield effect assumed to occur in 2007–08 with full adoption of the revised operating rules.

d Crop output valued at domestic market prices for rice and peanuts, shadow price for maize. Assumes no change in non-irrigation costs—data unavailable. Benefits from 2004–05 converted to Australian dollars at A$1 = 11,770 VND—actual exchange rates were used before 2004–05.

Source: Cu Chi Water Company.

Table 11. Project benefits from changes in summer/autumn rice yields, Ci Chi[a]

Year ended October	Total crop area[b] (ha)	Change in rice yield (t/ha)	Change in rice production[c] (tonnes)	Price of rice (VND/kg)	Project benefits[d]	
					(million VND)	(A$'000)
2002–03	4,397	0.0	0	1,800	0	0
2003–04	3,340	0.1	251	1,900	476	44
2004–05	3,340	0.2	501	1,900	952	81
2005–06	3,340	0.3	752	1,900	1,428	121
2006–07	3,340	0.4	1,002	1,900	1,904	162
2007–08	3,340	0.5	1 253	1,900	2,380	202
2008–09	3,340	0.5	1,253	1,900	2,380	202
2009–10	3,340	0.5	1,253	1,900	2,380	202
2011–24	3,340	0.5	1,253	1,900	2,380	202

[a] Effect of improved water distribution from adopting ACIAR project outcomes.

[b] Summer/autumn cropping area is assumed to remain unchanged from 2003–04 plantings and is used for rice production.

[c] Yield improvement assumed to apply to 75% of the impact area—some farms did not experience significant water deficits or excess water applications under the pre-existing operating procedures. Maximum yield effect assumed to occur in 2007–08 with full adoption of the revised operating rules.

[d] Crop output valued at domestic market price for rice. Assumes no change in non-irrigation costs—data unavailable. Benefits from 2004–05 converted to Australian dollars at A$1 = 11,770 VND—actual exchange rates were used before 2004–05.

Source: Cu Chi Water Company.

Table 12. Seasonal water usage in the Cu Chi irrigation system

Year ended October	Irrigated cropping		Water demand		Actual water supplied (million m³)	Excess water supply (million m³)
	area cultivated (ha)	utilisation rate[a] (%)	estimate (million m³)	application rate[b] (million m³/ha)		
2002–03[c]						
Winter/spring	6,236	43.0	95	–	107	12
Summer/autumn	4,397	30.3	69	–	90	22
Total	10,633	73.3	164	0.015	198	34
2003–04[d]						
Winter/spring	6,038	41.6	77	–	103	26
Summer/autumn	3,340	23.0	42	–	48	7
Total	**9,378**	**64.7**	**119**	**0.013**	**151**	**32**

[a] Proportion of total drainage area (14,500 ha) utilised.

[b] Derived as estimated water demand divided by the area cultivated.

[c] Water application rate based on pre-existing operating procedures.

[d] Water application rate based on partial adoption of operating procedures based on ACIAR project outcomes.

Source: Cu Chi Water Company.

It was assumed that the price would remain unchanged for the duration of the evaluation period. The CCWC expected sales of water to the municipal government to commence in the 2006–07 season. The evaluation assumed the entire water surplus generated by the change in operating procedures will be sold to council from 2006–07. The combined benefits of applying the research results to the Cu Chi irrigation scheme were estimated at A$1,675,000 in 2007–08:

- this involved a A$611,000 gain from improved crop yields and a A$1,064,000 benefit from the reduction in water use.

Table 13. Project benefits from changes in system water supplies, Cu Chi[a]

Year ended October	Irrigation area[b] (ha)	Application rate per ha[c] (million m^3)	System water supply			Project benefits[e]	
			revised rules (million m^3)	pre-existing rules[d] (million m^3)	change (million m^3)	(million VND)	(A$'000)
2002–03	10,633	0.019	198	198	0	0	0
2003–04	9,378	0.016	151	174	−23	0	0
2004–05	8,972	0.016	144	167	−23	0	0
2005–06	8,972	0.015	135	167	−32	0	0
2006–07	8,972	0.014	126	167	−41	10,281	874
2007–08	8,972	0.013	117	167	−50	12,524	1,064
2008–09	8,972	0.013	117	167	−50	12,524	1,064
2009–10	8,972	0.013	117	167	−50	12,524	1,064
2011–24	8,972	0.013	117	167	−50	12,524	1,064

a Effect of reducing water supplied to the irrigation system from adopting ACIAR project outcomes.

b Combined area of irrigated cropping land in the winter/spring and summer/autumn seasons.

c Rate of water supply for the combined seasonal irrigation areas under revised operating procedures. IMSOP model simulations by CCWC estimated crop demand application rate of 0.013 million m^3 per ha in 2003–04 (see Table 12). This was assumed to be the application rate achieved when the revised operating procedures were fully implemented in 2007–08.

d Based on 2002–03 application rate under pre-existing operating procedures.

e Water saving valued at the price paid by the HCM City municipal authority for untreated water (250 VND/m^3). Benefits from 2004–05 converted to Australian dollars at A$1 = 11,770 VND—actual exchange rates were used before 2004–05.

Source: Cu Chi Water Company.

5 Project net benefits

Estimates of the annual project benefits are presented in Table 14. Benefits are expressed in real (2003–04) Australian dollars. Over the 30-year evaluation period, the total benefits are estimated at just over A$35.4 million. They represent the combined economic benefits that accrue to the three irrigation companies and the farmers who use their irrigation services.

The evaluation has not attempted to value the environmental benefits that could arise from the projects. Lower water-application rates would reduce the environmental problems of waterlogged land and reduce the risk of increased salinity. Over time, this could provide important benefits for agricultural performance of the regions adopting the research results.

Estimated net benefits

The present value of the future stream of net benefits was estimated over a 30-year time horizon for a discount rate of 5 per cent. The project will deliver net benefits of A$13.2 million (Table 15). In present-value terms, the project costs were A$1.5 million (in 2003–04 dollars) and project benefits were A$14.7 million:

- this yields a benefit–cost ratio of almost 10 to 1.

The estimated net benefits for the full evaluation period are sensitive to assumptions on future levels of adoption. A progressive project evaluation can assess the project gains that have been achieved to date. In present-value term, the net benefits realised so far are A$0.3 million. This reflects the adoption of project advice up to the end of 2004–05:

- the progressive benefit–cost ratio is around 1.2.

Sensitivity analysis of project net benefits

A number of assumptions were required to assess the net benefit of the ACIAR projects. There is some uncertainty about the extent of the crop-yield benefits attributable to changes in operational rules. A critical assumption is how much of the seasonal cropping area would gain a yield benefit from an improved water supply and demand ratio:

- for the La Khe project the evaluation assumed two-thirds of the seasonal cropping area gained a yield benefit
- for the Dan Hoai and Cu Chi projects the evaluation assumed 75% of the seasonal cropping area gained a yield benefit.

It is worthwhile considering the sensitivity of the evaluation results to different assumptions for the crop areas that gain a yield benefit. Evaluations of system performance suggested the three schemes experienced widespread suboptimal water applications. However, it would be equally plausible to argue the extent of the yield gain was more or less widespread than was assumed.

To assess the sensitivity of this assumption, the project net benefits were calculated for alternative project impact areas. The sensitivity analysis used seasonal cropping areas that were 10% higher and lower than the assumptions used for the estimate in Table 15. The Cu Chi project impact, for example, was assessed for 65% and 85% of the seasonal cropping areas.

Changing these assumptions had a limited effect on the size of the project net benefits. In present-value terms, the project net benefits ranged from A$12 million and

Table 14. Economic benefits of water-management projects[a]

	La Khe scheme (A$'000)	Dan Hoai scheme (A$'000)	Cu Chi scheme (A$'000)	Total benefits (A$'000)	Exchange rate (VND per A$1)
1998–99	93	0	0	93	8,676
1999–00	187	0	0	187	8,619
2000–01	285	0	0	285	7,926
2001–02	377	0	0	377	7,960
2002–03	394	0	0	394	9,212
2003–04	412	56	149	617	10,861
2004–05	371	102	261	733	11,770
2005–06	361	149	327	837	11,770
2006–07	353	194	1,254	1,801	11,770
2007–08	344	236	1,518	2,098	11,770
2008–09	336	276	1,481	2,093	11,770
2009–10	327	270	1,445	2,042	11,770
2011–24	3,828	3,151	16,888	23,868	11,770
Total	7,668	4,434	23,322	35,423	

a Benefits converted to Australian dollars using annual exchange rates. Benefits expressed in real terms (2003–04 dollars)—inflation rate of 2.5% assumed for post 2003–04 period.

Table 15. Estimated net benefits ($A million) of water-management projects[a]

	Project costs	Project benefits	Net benefits
Full project evaluation[b]	1.5	14.7	13.2
Benefit–cost ratio	–	–	9.8
Progressive project evaluation[c]	1.5	1.8	0.3
Benefit–cost ratio	–	–	1.2

a Expressed in present value terms—discount rate of 5%. Benefits and costs valued in real terms (2003–04 dollars).

b Evaluation of net benefits for 30-year time horizon, 1994–95 to 2023–24.

c Evaluation of net benefits realised to date, 1994–95 to 2004–05.

A$14.5 million for the alternative assumptions (Table 15). This means the estimated net benefits would be around A$1.3 million lower (higher) if the original assumption proved to be overly optimistic (pessimistic).

Impact on rural poverty

Farm household poverty is an important issue in Vietnam. Many rural families have limited cash incomes and often rely on income supplements from family members with salaried jobs in urban areas. This project will contribute to a reduction in poverty for many farmers who rely on water from the three schemes benefiting from the ACIAR projects.

Higher crop yield from improved water management provides a direct financial benefit for farmers. It will provide extra cash incomes if the additional output is sold on the open market. For an average farm size of 0.3 ha the annual gain for farms affected by the revised operating rules would be around:

- A$29 for rice production in the La Khe and Dan Hoai schemes
- A$70 for summer/autumn rice production and combined winter/spring maize and peanut production in the Cu Chi scheme.

These estimates reflect the maximum yield gains from full adoption of the revised operating rules by the irrigation companies. The change in grain yields is valued at domestic market prices to reflect the actual gross income effect for farmers. Survey data collected for the projects indicate net farm income averages around A$403 in the La Khe system, A$517 in Dan Hoai and A$739 in Cu Chi. The poverty-reduction benefits are, therefore, equivalent to an increase in net farm income of approximately:

- 7% in La Khe system
- 6% in Dan Hoai system
- 10% in Cu Chi system.

Table 16. Sensitivity analysis of project net benefits[a]

	Net benefits (A$m) for project impact area		
	10% lower	**evaluation assumption**	**10% higher**
Full project evaluation[b]	12.0	13.2	14.5
Benefit–cost ratio	9.0	9.8	10.7
Progressive project evaluation[c]	0.1	0.3	0.6
Benefit–cost ratio	1.0	1.2	1.4

[a] Expressed in present value terms — discount rate of 5%. Benefits and costs valued in real terms (2003–04 dollars). Sensitivity analysis for project impact areas applied from 1998–99—all other assumptions were unchanged.

[b] Evaluation of net benefits for 30-year time horizon, 1994–95 to 2023–24.

[c] Evaluation of net benefits realised to date, 1994–95 to 2004–05.

6 Concluding comments

This project was a multifaceted study that focused on improvements in water management by three public irrigation schemes in Vietnam. The research demonstrated the potential gains that could be achieved from operational improvements in scheduling water deliveries. Adoption of the project results will improve the economic performance of farms that rely on irrigation water and the companies that manage these schemes.

Reviews of system performance indicated there were deficiencies in the capacity of the schemes to supply the required amount of water for seasonal cropping demands. In some cases, farms received excess water that affected farm performance because land became waterlogged. In other cases, farms experienced water deficiencies that affected crop yields through water stress at critical points in plant development.

A lack of financial resources has limited the opportunity to improve the performance of irrigation schemes through maintenance and physical development of the existing assets. Changing the operational rules for the existing infrastructure was an alternative way to improve the efficiency of water management. The ACIAR projects have demonstrated how government advisers can assess and address this issue.

Evaluation of the ACIAR research has shown that revised operating rules can have two benefits. The primary benefit is a financial gain for farmers from improved crop yields. A closer alignment of water supplies with crop demands will increase output for existing planting decisions that mostly involve rice production. In some situations it could enhance the opportunity to diversify into dryland crops:

- a reduction in waterlogged land could encourage more farmers to grow three crops per year and improve the productive performance of the irrigation schemes.

A second benefit can be obtained through reduced water usage where the existing operational rules contributed to an oversupply of water. Irrigation companies can lower their operating costs through reducing pumping time or reduced bulk-water costs. This would improve their financial performance and reduce the requirement for public subsidies.

The economic benefits relate to gains in farm-level productivity and reduced costs in providing the irrigation services. Increased farm incomes will help to reduce poverty among the farmers who rely on the irrigation schemes. Improved water-management efficiency will also have longer-term environmental benefits by reducing soil degradation due to increased salinity levels.

Adoption of the research results in one scheme (La Khe) has been encouraging. Water-pumping costs have been reduced and crop yields have improved. However, a lack of data from field trials or monitoring post-adoption farm performance has required the evaluation to rely on several assumptions. The evaluation results should be viewed in this light:

- information to develop assumptions for the La Khe and Dan Hoai schemes was limited
- an extra research activity would have helped to verify the potential benefits.

In present-value terms, the estimated net benefits of the three projects are around A$13 million for the 30-year evaluation period, generating a benefit–cost ratio of about 10 to 1. This estimate is conditional on the assumptions used to reflect the impact on crop yields and the size of the seasonal cropping areas affected by the revised operating rules:

- a sensitivity analysis on the project impact area indicated the net benefits could range between A$12 million and A$15 million.

The ACIAR projects have made a valuable contribution towards building Vietnam's capacity to assess the operational performance of publicly managed irrigation schemes. The research showed that physical infrastructure improvements and switching to a volume-based pricing mechanism could lead to further gains in water-management efficiency.

Application of this approach to other schemes could also lead to wider economic benefits for the rural economy. However, there was no indication of a wider adaptation of the research at the time of the evaluation. In time the research may be adapted and applied to other schemes. This could lead to greater gains in water-management efficiency in Vietnam and a portion of those gains would be attributable to these ACIAR projects.

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IMPACT ASSESSMENT SERIES

No.	Author(s) and year of publication	Title	ACIAR project numbers
1	Centre for International Economics (1998)	Control of Newcastle disease in village chickens	8334, 8717 and 93/222
2	George, P.S. (1998)	Increased efficiency of straw utilisation by cattle and buffalo	8203, 8601 and 8817
3	Centre for International Economics (1998)	Establishment of a protected area in Vanuatu	9020
4	Watson, A.S. (1998)	Raw wool production and marketing in China	8811
5	Collins, D.J. and Collins, B.A. (1998)	Fruit fly in Malaysia and Thailand 1985–1993	8343 and 8919
6	Ryan, J.G. (1998)	Pigeon pea improvement	8201 and 8567
7	Centre for International Economics (1998)	Reducing fish losses due to epizootic ulcerative syndrome—an ex ante evaluation	9130
8	McKenney, D.W. (1998)	Australian tree species selection in China	8457 and 8848
9	ACIL Consulting (1998)	Sulfur test KCL–40 and growth of the Australian canola industry	8328 and 8804
10	AACM International (1998)	Conservation tillage and controlled traffic	9209
11	Chudleigh, P. (1998)	Post-harvest R&D concerning tropical fruits	8356 and 8844
12	Waterhouse, D., Dillon, B. and Vincent, D. (1999)	Biological control of the banana skipper in Papua New Guinea	8802-C
13	Chudleigh, P. (1999)	Breeding and quality analysis of rapeseed	CS1/1984/069 and CS1/1988/039
14	McLeod, R., Isvilanonda, S. and Wattanutchariya, S. (1999)	Improved drying of high moisture grains	PHT/1983/008, PHT/1986/008 and PHT/1990/008
15	Chudleigh, P. (1999)	Use and management of grain protectants in China and Australia	PHT/1990/035
16	McLeod, R. (2001)	Control of footrot in small ruminants of Nepal	AS2/1991/017 and AS2/1996/021
17	Tisdell, C. and Wilson, C. (2001)	Breeding and feeding pigs in Australia and Vietnam AS2/1994/023	
18	Vincent, D. and Quirke, D. (2002)	Controlling *Phalaris minor* in the Indian rice–wheat belt	CS1/1996/013
19	Pearce, D. (2002)	Measuring the poverty impact of ACIAR projects—a broad framework	
20	Warner, R. and Bauer, M. (2002)	*Mama Lus Frut* scheme: an assessment of poverty reduction	ASEM/1999/084
21	McLeod, R. (2003)	Improved methods in diagnosis, epidemiology, and information management of foot-and-mouth disease in Southeast Asia	AS1/1983/067, AS1/1988/035, AS1/1992/004 and AS1/1994/038
22	Bauer, M., Pearce, D. and Vincent, D. (2003)	Saving a staple crop: impact of biological control of the banana skipper on poverty reduction in Papua New Guinea	CS2/1988/002-C
23	McLeod, R. (2003)	Improved methods for the diagnosis and control of bluetongue in small ruminants in Asia and the epidemiology and control of bovine ephemeral fever in China	AS1/1984/055, AS2/1990/011 and AS2/1993/001
24	Palis, F.G., Sumalde, Z.M. and Hossain, M. (2004)	Assessment of the rodent control projects in Vietnam funded by ACIAR and AUSAID: adoption and impact	AS1/1998/036
25	Brennan, J.P. and Quade, K.J. (2004)	Genetics of and breeding for rust resistance in wheat in India and Pakistan	CS1/1983/037 and CS1/1988/014
26	Mullen, J.D. (2004)	Impact assessment of ACIAR-funded projects on grain-market reform in China	ANRE1/1992/028 and ADP/1997/021
27	van Bueren, M. (2004)	Acacia hybrids in Vietnam	FST/1986/030
28	Harris, D. (2004)	Water and nitrogen management in wheat–maize production on the North China Plain	LWR1/1996/164
29	Lindner, R. (2004)	Impact assessment of research on the biology and management of coconut crabs on Vanuatu	FIS/1983/081

IMPACT ASSESSMENT SERIES <CONTINUED>

No.	Author(s) and year of publication	Title	ACIAR project numbers
30	van Bueren, M. (2004)	Eucalypt tree improvement in China	FST/1990/044, FST/1994/025, FST/1984/057, FST/1988/048, FST/1987/036, FST/1996/125 and FST/1997/077
31	Pearce, D. (2005)	Review of ACIAR's research on agricultural policy	
32	Tingsong Jiang and Pearce, D. (2005)	Shelf-life extension of leafy vegetables—evaluating the impacts	PHT/1994/016
33	Vere, D. (2005)	Research into conservation tillage for dryland cropping in Australia and China	LWR2/1992/009, LWR2/1996/143
34	Pearce, D. (2005)	Identifying the sex pheromone of the sugarcane borer moth	CS2/1991/680
35	Raitzer, D.A. and Lindner, R. (2005)	Review of the returns to ACIAR's bilateral R&D investments	
36	Lindner, R. (2005)	Impacts of mud crab hatchery technology in Vietnam	FIS/1992/017 and FIS/1999/076
37	McLeod, R. (2005)	Management of fruit flies in the Pacific	CS2/1989/020, CS2/1994/003, CS2/1994/115 and CS2/1996/225
38	ACIAR (2006)	Future directions for ACIAR's animal health research	
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40	Corbishley, J. and Pearce, D. (2006)	Zero tillage for weed control in India: the contribution to poverty alleviation	CS1/1996/013
41	ACIAR (2006)	ACIAR and public funding of R&D, Submission to Productivity Commission study on public support for science and innovation	
42	Pearce, D. and Monck, M. (2006)	Benefits to Australia of selected CABI products	
43	Harris, D.N. (2006)	Water management in public irrigation schemes in Vietnam	LWR2/1994/004 and LWR1/1998/034

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No.	Author(s) and year of publication	Title	ACIAR project numbers
1	Doeleman, J.A. (1990)	Biological control of salvinia	8340
2	Tobin, J. (1990)	Fruit fly control	8343
3	Fleming, E. (1991)	Improving the feed value of straw fed to cattle and buffalo	8203 and 8601
4	Doeleman, J.A. (1990)	Benefits and costs of entomopathogenic nematodes: two biological control applications in China	8451 and 8929
5	Chudleigh, P.D. (1991)	Tick-borne disease control in cattle	8321
6	Chudleigh, P.D. (1991)	Breeding and quality analysis of canola (rapeseed)	8469 and 8839
7	Johnston, J. and Cummings, R. (1991)	Control of Newcastle disease in village chickens with oral V4 vaccine	8334 and 8717
8	Ryland, G.J. (1991)	Long term storage of grain under plastic covers	8307
9	Chudleigh, P.D. (1991)	Integrated use of insecticides in grain storage in the humid tropics	8309, 8609 and 8311
10	Chamala, S., Karan, V., Raman, K.V. and Gadewar, A.U. (1991)	An evaluation of the use and impact of the ACIAR book Nutritional disorders of grain sorghum	8207
11	Tisdell, C. (1991)	Culture of giant clams for food and for restocking tropical reefs	8332 and 8733
12	McKenney, D.W., Davis, J.S., Turnbull, J.W. and Searle, S.D. (1991)	The impact of Australian tree species research in China	8457 and 8848
	Menz, K.M. (1991)	Overview of Economic Assessments 1–12	